Forecasting Research Division
Technical Report No. 54

Operational changes affecting the quality control of atmospheric data used by the Unified Model during 1992

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1. Introduction

This report documents operational changes through 1992 that affected the flagging of atmospheric data by the Unified Model quality control (QC) scheme - the QC scheme is described in Ingleby and Parrett (1991). It follows on from the report by Ingleby (1991), subsequently referred to as I91, which discussed the changes up to October 1991. To aid comparison, the format here is similar to that in I91, with the same sequence of data types, etc.. Time-series are presented first, showing the percentages of rejections for most observation types, which help illustrate the effects of the changes. More detailed statistics are presented for October 1992; these are compared with similar statistics for October 1991 presented in I91.

2. Changes related to the time-series of rejections

The time-series presented here cover the period from 15th October 1991 to the end of December 1992, so there is an overlap of two weeks with the time-series in I91. The time-series have been produced from data stored in the global model observation processing database (OPD), using the Statistical Analysis Software (SAS) and SAS/GRAPH packages. As in I91, the statistics are calculated for each week beginning on a Tuesday, because the operational changes are made on Tuesdays - a list of the changes that may have affected the statistics is given in Appendix A.

The number of observations of each data type in the OPD are displayed in Figure 1 (NB 120km Satems are not stored in the OPD). (The last point represents only 3 days, rather than a week.) There are few substantial changes for most data types. Many of the dips in numbers are either due to temporary transmission/receiving problems (e.g. the dip in SATEMs for week beginning 8/1/92), or due to problems with a particular data type causing Unified Model (UM) runs to fail and leading to that data type being switched off by the computer operators to get the UM to run successfully (e.g. synops and ships for the week beginning 31st December 1991). Other points to note are: (i) the large increase in aircraft reports in ASDAR code when AMDARs were included on 10th December 1991; (ii) problems with drifting buoys 29/10/91 - 10/12/91 (possibly

associated with the change from DRIBU to DRIFTER code) and again 31/12/91 - 28/01/92, when few, if any, reports reached the OPD; (iii) a spike in the number of AIREPs at the beginning of March 1992, caused by reports being re-transmitted from Carswell; and (iv) a sudden increase in LASS data from 5th May 1992, when NOAA 12 reports were processed, in addition to NOAA 11 reports.

2.1 Surface observations

(a) Pressure

Figures 2(a)-(c) show the percentages of pressure rejects for synops, ships and drifting buoys, respectively. There is a seasonal trend in the percentage of synop pressures flagged (Figure 2(a)) with an increase in flagging in the northern hemisphere winter (not seen for ships - Figure 2(b)), which may be due to model boundary layer problems or local effects over land causing large differences from background. But the main change in the percentage of synop pressures flagged, was the reduction on 7th July 1992. From this date, reported mean sea level pressure ($P_{msl\text{-}rep}$) has been used for stations below 500m, instead of P_{msl} calculated from reported station level pressure, $P_{msl\text{-}stn}$ (Wright, 1993). The number of $P_{msl\text{-}stn}$ reports in the OPD fell from ~70000 per week to ~20000, while the number of $P_{msl\text{-}rep}$ reports rose from ~50000 to ~100000. The percentage of rejections of $P_{msl\text{-}stn}$ rose by about 3% after 7th July, indicating the poorer quality of the higher level stations remaining; while the percentage of rejections of $P_{msl\text{-}rep}$ fell, giving the overall drop seen in Figure 2(a), and indicating the better quality of the low level $P_{msl\text{-}rep}$ reports compared to the calculated $P_{msl\text{-}stn}$s. This probably implies that wrong station heights were used in the calculation of $P_{msl\text{-}stn}$ for some of these stations below 500m. Our results here agree broadly with those presented by Wright (1993).

[N.B. In I91, it was stated that there was a significant reduction of P flags (his Figure 2) from 26th March 1991, due to a correction to the processing. In fact this was not the case - there was a change in the OPD format of $P_{msl\text{-}stn}$ reports. After 26th March 1991, figure 2 in I91 contains only the $P_{msl\text{-}rep}$ reports, excluding the $P_{msl\text{-}stn}$ reports (~50% of the P reports),

of which ~7% were flagged. The overall percentage of P reports flagged remained reasonably constant at ~4.5%.]

The large peak in final flags for the week beginning 31/12/91 was due to all synops being flagged by the intervention forecaster in the Central Forecast Office (CFO) for 3 days, prior to the correction of a bug in the observation processing program on 3/1/92. Another noticeable change in the percentage of synop pressure flags occurred for the week beginning 1st December 1992, when there was a drop in the percentage failing the background check, caused by the changes to the background errors (BGEs). The steady increase in flags during December 1992 seems to be part of the annual cycle, mentioned above.

Figures 2(b) and 2(c) show a larger weekly variation in percentage of ship and drifting buoy pressures flagged than is seen in the synop time-series. This is partly due to the greater variability in the numbers of reports, the smaller numbers involved and different ships reporting. The 'monthly' updates to the ship and drifter permanent rejection and correction lists impact on the percentage with a final flag directly and may have a small effect on the percentage with buddy check flags if more or less bad reports get through to the buddy check (permanent rejects are not buddy checked).

The reduction in background flags of ship pressures on 12th May 1992 may be related to improvements in the UM when it changed to version 2.5, but the reduction seems to have been sustained for only about 3 weeks. Overall there is a slight downward trend in the number of background flags of ship Ps, from ~3.5% in October 1991 to ~2.5% in December 1992, which is reflected in the percentage with a final flag (~6% to ~5%).

The larger rejection rates of drifter pressures in November 1991 and January 1992 are related to the data problems when only a few reports were received in the OPD. The large percentage of final flags seen in Figure 2(c) (about 20%), is due to the (random) thinning of drifting buoy reports within the quality control, which limits the number within the 6-hour time-window to a maximum of 5, flagging the remainder.

(b) Wind

The time-series of ship wind reports, Figure 2(d), shows that the largest change in percentage of background flags was for the week beginning 10th December 1991, when it fell from ~4.5% to ~3.5%. This was due to the reduction in the tophat function used in the quality control of ship winds, from 0.0018 to 0.0010; this was in response to comments from CFO forecasters that too many ship winds were being flagged. The change clearly had the desired effect.

The tuning to the QC on 1st December 1992 was to counteract the changes to the BGEs and observation errors and, as intended, it had no discernable effect on the percentage of winds flagged. The step jumps in final flags of ship winds on 10th March 1992 (~ +2%) and 13th October 1992 (~ +3%) were the result of updates to the list of permanent rejects. Together, they resulted in an approximate doubling of ship wind flags.

2.2 Aircraft observations

The time-series of aireps above 400mb are shown in Figures 3(a) and 3(b). They show a large increase in final flags of both wind and temperature at the beginning of January 1992, from ~4% to ~20% - caused by the rejection of all aireps over the USA. There is also a large peak of up to 49% around 1st - 17th March, coinciding with the large peak in airep numbers (seen in Figure 1) caused by the receipt of aireps re-transmitted from Carswell. On 9th June 1992 the percentage of final flags dropped when the permanent rejection list was updated and some airline's observations were no longer rejected.

There was a change on 3rd November 1992 to exclude observations from the buddy check if they were more than 15 standard deviations from the background (previously the limit was 25 standard deviations). This will have led to a small reduction in the number of buddy check flags (just discernable in Figures 3(a) and 3(b)), but no change in the number of final flags. The reduction in the number of buddies on 1st December 1992 should have produced a slight reduction in flagging (according to test runs), but the

small reduction just visible in Figures 3(a) and 3(b) may also be due to the enhanced BGEs near 'supported' aireps.

The percentage of background flags of airep winds (Figure 3(a)) shows something of an annual cycle, rising from ~2.3% in October 1991 to peak in January 1992 at ~4.0%, then decreasing to below 1.5% in August and increasing again to ~2.0-2.5% in October - December 1992. This probably reflects the greater strengths of the jetstream winds in the northern hemisphere winter and the faster movement of troughs and ridges then. Figure 3(b) shows that the percentage of temperatures flagged by the background check is reasonably constant, around 2%.

The percentage of asdars rejected (Figures 3(c) and 3(d)) is much lower than for aireps, being generally < 0.5%, reflecting the higher quality of the automated data. [The values of observation errors and initial PGE were the same for both aireps and asdars, but it is now planned to reduce those for the automated data to give them more weight in the assimilation.] There was little change in percentage of rejects when the volume of data increased by a factor of 5 in December 1991. The reasons for most of the spikes in the asdar time-series are unknown, but some may be due to certain aircraft instruments becoming faulty and then being mended or taken out of service.

2.3 Satellite cloud track-winds (satobs)

Figures 4(a)-4(c) show the time-series of background flags for the high, medium and low level satellite cloud-track winds that are used operationally. The winds from Meteosat seem to be the best quality, with the lowest rejection rates: generally 1-3% for high and medium level winds and averaging ~0.1 % for low level winds. There was an increase in rejection rates at all levels when Meteosat 4 was replaced by Meteosat 5 for the period 26th - 29th November 1991. The reason for the large increase in high level flags around 24/12/91 - 7/1/92 is unknown.

Winds from the Japanese satellite (GMS) have the next lowest rejection rates: ~5-10% at high levels and 0.1-0.9% at low levels. The percentage of flagged high level GMS winds fell on 1st

December 1992. This may be due to increased BGEs effectively relaxing the quality control; because there are a large number of aircraft reports over the Pacific Ocean between 200 and 300mb, many of which are given 'supported' flags by intervention forecasters in the CFO, and from 1st December 1992 caused the BGEs in these areas to be increased. This change does not seem to have affected winds from the other satellites, possibly because there were fewer aircraft reports in their areas of coverage.

GOES winds have the highest rejection rates: ~18-30% at high levels, ~10-25% at medium levels and generally 0.2-1.0% at low levels after the change on 19th November 1991 to remove the effect of eroneous temperatures (by setting $PGE_{loc} = 0.0$) below 800mb. All three levels of GOES winds show something of a general reduction in percentage flagged up until about May 1992 - possibly due to improvements in the GOES processing?

2.4 Bogus observations

Intervention forecasters in CFO produce bogus observations to either add support to existing observations, or to insert synoptic features visible in satellite imagery, or on the basis of tropical cyclone advisories. In each case the background is presumably in error and the BGEs used in the quality control and assimilation should be large, to increase the likelihood of the bogus (and nearby) observations passing the quality control and also increase the weight given to the observations in the assimilation. Prior to 1st December 1992, the BGE was increased for bogus (and 'supported') observations within the quality control, but only for the background check. On 1st December this increase was reduced somewhat as another program was introduced operationally to enhance the fields of BGEs around bogus (and 'supported') observations in a smooth way. These enhanced BGEs are used throughout the quality control and in the assimilation for both the bogus observations and any nearby observations (the enhancement drops off to zero about 10° latitude/longitude and about 150mb (in troposphere) away from the bogus observation). This helps the bogus observation, and any nearby observations that it supports, to pass the quality control and to give extra weight

to these observations in the assimilation, so that the analysis fits them better. Consequently, fewer bogus observations are required to produce the same effect and there was a drop in the number of bogus observations (just visible in Figure 1), as intervention forecasters became aware of this fact. The time-series of flagged bogus observations are very noisy, as seen in Figures 5(a) and 5(b), but there may be some signs of a reduction in percentage flagged after 1st December 1992.

Despite the noise, there does seem to be a general trend for the percentage of rejected bogus to have decreased during 1992, from a high around December 1991 and January 1992 of ~3% for pressure and ~6% for upper winds down to ~1% for both pressure and winds.

The introduction of the buddy check on 31st March 1992 for bogus upper level winds and temperatures had little impact, because few radiosonde reports are within buddy check range of the bogus observations - bogus observations are not buddy checked against each other in case of positioning errors common to a block of bogus observations. The differences between the percentage of buddy check and final flags in Figures 5(a) and 5(b) are caused by observations that are very far from the background values not being used in the buddy check and hence not having a buddy check flag; although, for Figure 5(a), some of the differences may be due to some bogus observations being over model land points with an elevation in excess of 1000m - these are given prior reject flags.

There were very few of the bogus thickness observations flagged (most weeks none); and for about half of the weekly periods no bogus upper level temperatures or relative humidities were flagged, although for just a few weeks ~10% were flagged.

2.5 NESDIS 500km satellite soundings (SATEMs)

There was a large temperature bias in the UM at version 2.3, resulting in most of the top layers of the satems being flagged. To counteract this, the quality control of satems above 10mb was relaxed on 19th November 1991 by multiplying the initial PGE by

0.2 and the error variance by 2.0, and by removing a separate 'Part C' check. Little impact is seen in the time-series shown in Figure 6, because the number of reports above 10mb is relatively small, but the percentage of satems flagged above 10mb did drop.

The sudden reduction in final flags on 4th February 1992, lasting for two weeks, was due to a similar reduction in prior flags - possibly caused by a mistake in the station list removing the permanent reject on all satems over land. The percentage of prior flags increased on 18th February anyway, when 120km satellite soundings (SAT120s) were included in the assimilation, due to collocation checks with the SAT120s. The dips in the percentage of final flags after this are mostly where the volume of SAT120 data was substantially reduced for various reasons, resulting in fewer collocation flags.

The percentage of satems flagged in the troposphere by the stability check is relatively constant around 22%, similar to the percentage flagged since July 1991 (see I91). The percentage of reports with a background flag at any level shows something of a dip from April to July 1992, followed by a sudden increase from ~20% to nearly 50% on 6th October, coinciding with when the number of levels in the UM was reduced from 20 to 19. Most of these flags were at the top layer (10-7mb), indicating that the change made the background heights worse above 10mb.

The soundings with a tropospheric or stratospheric flag are those failing a multi-layer check on all layers below or above 100mb - at least 2 suspect layers or 1 flagged layer, away from the bottom or top layer, respectively. The percentage of these flags was generally < 1%, but the percentage of stratospheric flags increased markedly in August 1992 to between 2 and 4%, at the same time as the percentage of background flags also increased, possibly associated with the change to UM version 2.6.

2.6 Local Area Satellite Soundings (LASS)

Figure 7 shows the time-series of rejections of LASS data - the final flags are not shown because an error caused them to be set incorrectly for LASS data over land (the whole report flags were

correct though, and the correct data was assimilated). The percentage of LASS with prior flags (soundings over land) was reasonably constant around 40% until 5th May 1992, when it rose to about 60%. This was due to the inclusion of data from the NOAA 12 satellite, which produced a three-fold increase in data volume.

Prior to 3rd March 1992, the percentage of LASS reports with a background flag at any level was very variable (~5-75%). The high values in January probably being due to the temperature bias at high levels in the UM (possibly improved with version 2.4 on 11th February) causing 1 or 2 LASS levels in the stratosphere to be flagged. Immediately after 3rd March, when a bug in the observation processing program was corrected, the percentage of background flags fell to < 5% and slowly fell further to ~1% by August 1992.

The percentage of flags set within the LASS processing (brightness temperature relative probability (BTRP), elevation and retrieval route flags) was mostly constant at ~15%, except for 2 spells: November 1991 (up to ~33%) and January 1992 (up to ~28%). The November spell coincides with an increase in the tropospheric vertical stability flags, indicating poorer quality data in the troposphere; whereas the January spell coincides with the peak in background flags and was probably due to poorer quality data and/or background temperatures in the stratosphere.

The LASS time-series ends on 1st September 1992, from which date LASS data has been stored in the Meteorological Data Base (MDB) instead of in the OPD. Due to feed-back problems, with the LASS data causing a model temperature bias (compared to radiosonde temperatures), the LASS data has been rejected since 14th October 1992.

2.7 Radiosonde observations

The time-series of percentage of radiosonde flags, split into three pressure bands, are given in Figures 8(a)-8(i). The changes on 19th November 1991 had a generally small impact on the flags, with a slight reduction in background flags of temperature (Figures 8(b), 8(e) and 8(h)) due to the change in the error

profiles and in the Hawson corrections. The reduction in initial PGE for sonde relative humidities (0.050 -> 0.015) led to a reduction in background flags at medium and high levels (Figures 8(c) and 8(f); whereas at low levels (Figure 8(i) the reduction in BGEs outweighed the reduction in PGE and caused an increase in relative humidity background flags.

Figure 8(a) shows that the percentage of sonde winds above 400mb that were rejected by the background check was generally about 0.8% prior to 9th June 1992, except for a peak of up to 2% in January 1992. This January peak is also seen in the background flags of sonde temperatures (Figure 8(b)), LASS temperatures (Figure 7), satem temperatures (Figure 6), upper level bogus winds (Figure 5(b)) and Meteosat winds above 400mb (Figure 4(a)). These results suggest that this was a period when the UM backgrounds were poor in the north Atlantic sector, and this was the case, with a large positive temperature bias in the stratosphere. The start of the period corresponds approximately with the start of the rejection of all aireps over the USA (possibly unrelated), while the end of the period corresponds approximately with the relaxation of the quality control of sonde temperatures above 100mb north of 40°N. The introduction of UM version 2.4 seems to have also reduced the percentage of sonde wind flags.

The inclusion of representivity error for unaveraged sonde temperatures on 10th March 1992 reduced the number of final flags of higher level temperatures (especially above 400mb - Figure 8(b)) by ~1%. The sonde-sonde buddy check introduced on 31st March generally reduced the percentage flagged by a small amount, mostly < 0.1%; although the reduction in flags was greater for high level temperatures from November 1992, possibly due to the tighter exclusion limit for the buddy check on 3rd November. The introduction of the revised long-wave radiation scheme in the UM on 7th April seems to have improved the model at higher levels and led to a slight reduction in sonde wind and temperature flags (Figures 8(a) and 8(b)).

The most consistent change to the sondes for wind, temperature and relative humidity at all levels, was the reduction in background, buddy check and final flags on 9th June 1992 (e.g.

background/final flags of high level winds reduced from 0.7/1.1% to 0.4/0.6%). This was due to the change in the vertical averaging, whereby standard and significant levels with high PGEs were omitted, and also, for relative humidity, due to the relaxation in its quality control.

The high percentage of relative humidity final flags at high and medium levels was due to the prior rejection of relative humidity when associated temperatures were below -40°C. This was removed temporarily from 1st- 7th September 1992 and permanently on 13th October. The intention had been to replace it with a similar cut-off within the quality control, based on averaged temperatures, but, as can be seen from the sudden reduction in final flags on 13th October, this was not the case - due to an error in the quality control program (corrected on 2/3/93). Test runs indicated that the inclusion of high level RHs improved the forecasts (at least when verified against sonde RHs); consequently, it is intended to remove the -40°C cut-off for the more accurate chemical humidity sensors, when they can be reliably identified.

3. Statistics for October 1992

This section contains a summary of the quality control decisions in October 1992. October was chosen so that comparisons can be made with the results for October 1991, presented in I91 (October 1991 results are given in brackets and italics in the text below). As in I91, contingency tables are used to compare the background and buddy check flags, etc., and horizontal bar charts are used for multi-level data.

3.1 Surface

Table 1(a) shows that 98.95% *(99.19%)* of synop $P_{msl\text{-}rep}$ reports passed the background check and 98.20% *(98.51%)* passed the final check. Whereas only 94.03% of synop $P_{msl\text{-}stn}$ reports (Table 1(b)) passed the background check and only 87.49% passed overall. Of the prior rejects of synop P, over 80% passed the background check,

indicating that their o-b biasses must be quite small. The 'other' flags are where the differences from background of P_{msl} and P^* disagree - mainly a few high level stations.

Table 1. Contingency tables of quality control decisions for surface observations in October 1992.

(a) Synop $P_{msl-rep}$ (431907 obs)

Background		Prior	CFO	Buddy	Other	Pass	
	Pass	0.60	0.00	0.42	0.00	97.94	98.95
	Fail	0.06	0.00	0.63	0.09	0.27	1.05
		0.66	0.00	1.04	0.09	98.20	100.00%

(b) Synop $P_{msl-stn}$ (91022 obs)

Background		Prior	CFO	Buddy	Other	Pass	
	Pass	4.06	0.00	3.14	0.00	86.82	94.03
	Fail	0.82	0.00	3.58	0.90	0.67	5.97
		4.88	0.00	6.73	0.90	87.49	100.00%

(c) Ship P_{msl} (77537 obs)

Background		Prior	CFO	Buddy	Other	Pass	
	Pass	0.47	0.55	1.16	0.00	94.64	96.82
	Fail	0.14	1.08	1.63	0.09	0.24	3.18
		0.61	1.64	2.79	0.09	94.88	100.00%

(d) Drifter P_{msl} (42252 obs)

Background		Prior	CFO	Buddy	Other	Pass	
	Pass	1.69	0.00	0.29	14.63	80.70	97.31
	Fail	2.04	0.00	0.39	0.13	0.13	2.69
		3.72	0.00	0.68	14.76	80.83	100.00%

(e) Ship wind (76418 obs)

Background		Prior	CFO	Buddy	Pass	
	Pass	4.04	0.26	0.25	92.36	96.91
	Fail	0.21	0.48	2.12	0.28	3.09
		4.25	0.74	2.37	92.64	100.00%

Table 1(c) shows that 96.82% *(96.42%)* of ship pressures passed the background check and 94.88% *(93.79%)* passed overall. About 2/3 of CFO rejects of ship pressures (and winds - Table 1(e)) would have been flagged anyway (as in October 1991).

The percentage of drifting buoy pressures that passed the background check in October 1992 (97.31%) was slightly down from the percentage in October 1991 *(98.70%)*; although the percentage with a final flag (19.17% cf *18.73%*) was largely composed of 'thinned' drifters ('other' flags), as in October 1991.

In October 1992, as in October 1991, the buddy check rejected more pressure observations than it reinstated, especially so for synop $P_{msl-stn}$ reports (3.14% cf 0.67%).

Table 1(e) shows that only 3.1% of ship winds failed the background check, compared with *4.3%* in October 1991 prior to the reduction in tophat function on 10th December 1991. The buddy check reinstated a similar fraction of ship winds as it flagged. Of the prior rejects, ~95% passed the background check, suggesting that some of these should not have been on the permanent rejection list.

3.2 Aircraft

The number of automated aircraft reports has increased rapidly over the past 2 years and the number of asdar reports in October 1992 was over 10 times that for October 1991. Table 2 shows the flagging for airep and asdar winds and temperatures for October 1992. Comparing (a) and (b) with (c) and (d), the better quality of the automated asdar reports can clearly be seen, with only 0.38% *(0.78%)* and 0.50% *(1.24%)* of asdar winds and temperatures, respectively, flagged overall. These compare with 8.98% *(4.49%)* and 9.39% *(3.06%)* for aireps, of which over 7% were prior flags - reports from aircraft on a blacklist of known poor quality observations. There were no asdars on a permanent rejection list.

As in October 1991, the buddy check still rejects more aircraft observations than it reinstates - ~1.5 times more winds (0.24% cf 0.17% for aireps and 0.05% cf 0.03% for asdars), nearly 3 times more airep temperatures (0.28% cf 0.10%) and nearly 7 times more asdar temperatures (0.27% cf 0.04%).

Again as in 1991, over half of the aircraft winds and 2/3 of the temperatures that CFO flagged would have been flagged by the background check anyway. Of the reports supported by CFO (5996 winds and 138 temperatures), all of the temperatures passed the quality control, but 1.5% of the winds were flagged - 0.7% by the background check and 0.8% by the buddy check only.

Table 2. Contingency tables of quality control decisions for aircraft observations in October 1992.

(a) Airep winds (177265 obs)

		Prior	CFO	Buddy	Calm	Pass	
Background	Pass	6.26	0.37	0.24	0.46	90.86	98.19
	Fail	0.83	0.39	0.42	0.01	0.17	1.81
		7.09	0.76	0.65	0.47	91.02	100.00%

(b) Asdar winds (136605 obs)

		CFO	Buddy	Calm	Other	Pass	
Background	Pass	0.02	0.05	0.23	0.03	99.59	99.90
	Fail	0.01	0.05	0.00	0.00	0.03	0.10
		0.03	0.10	0.23	0.03	99.62	100.00%

(c) Airep temperatures (179020 obs)

		Prior	CFO	Buddy	Other	Pass	
Background	Pass	6.73	0.33	0.28	0.00	90.51	97.86
	Fail	0.38	0.58	1.05	0.03	0.10	2.14
		7.11	0.91	1.33	0.04	90.61	100.00%

(d) Asdar temperatures (147644 obs)

		Prior	CFO	Buddy	Other	Pass	
Background	Pass	0.00	0.08	0.27	0.03	99.47	99.84
	Fail	0.00	0.02	0.10	0.00	0.04	0.16
		0.00	0.10	0.37	0.03	99.50	100.00%

The number of aireps that reported calm winds (0.47%) was less than half that for October 1991, but still rather high; and the percentage of calm asdars has increased from October 1991 *(0.02%)* to 0.23%. Of the aireps with permanent reject (prior) flags, only 12% of winds and 5% of temperatures failed the background check, indicating that not all of these observations were bad.

3.3 Satellite cloud-track winds (satobs)

Table 3 shows that the satob-satob buddy check continues to reinstate many times more observations than it rejects. This is particularly so for Meteosat, which reinstates 0.22% *(0.28%)*. As in October 1991, about 2/3 of CFO rejects would have failed the background check anyway. The actual percentage failing the background check (3.28%) is less than that for October 1991 *(4.34%)*, which may indicate that the data has improved somewhat,

or it may just be due to different prevailing weather conditions in 1991.

Table 3. Contingency table of quality control decisions for satellite cloud-track winds in October 1992.

(219366 obs)		Prior	CFO	Buddy	Pass	
Background	Pass	5.45	0.08	0.01	91.18	96.72
	Fail	1.14	0.16	1.82	0.16	3.28
		6.59	0.24	1.83	91.34	100.00%

3.4 Bogus observations

Tables 4(a) and 4(b) show that very few surface bogus observations were flagged by the background check, only 0.43% *(1.33%)* of pressures and 0.29% *(0.13%)* of winds. The 5% of winds with a prior flag are reports over model land points - all surface wind reports over land are permanently rejected.

Table 4. Contingency tables of quality control decisions for CFO bogus observations in October 1992.

(a) Bogus P_{msl}

(5534 obs)		Prior	Buddy	Other	Pass	
Background	Pass	0.04	0.61	0.00	98.92	99.57
	Fail	0.00	0.09	0.05	0.29	0.43
		0.04	0.70	0.05	99.20	100.00%

(b) Bogus 10m wind

(3068 obs)		Prior	Buddy	Pass	
Background	Pass	5.05	0.00	94.65	99.71
	Fail	0.00	0.29	0.00	0.29
		5.05	0.29	94.65	100.00%

(c) Upper level bogus

	Number	Background Flag (%)	Pass (%)
Wind	6009	1.60	98.40
Temperature	647	0.31	99.69
Relative Hum.	1349	0.67	99.33
Thickness	677	0.00	100.00

The buddy check with other surface observations (bogus observations do not buddy check each other) resulted in more than twice as many bogus pressures being flagged as being reinstated, but had no effect on bogus wind flags. Upper level bogus

observations do not undergo a buddy check and very few were flagged by the background check (Table 4(c)) - no thicknesses, only 0.31% *(1.82%)* of temperatures, 0.67% *(0.00%)* of relative humidities, but slightly more bogus winds at 1.60% *(1.12%)*. Many of the bogus winds that were flagged were in or near very strong jetstreams, where relatively small differences in direction between the bogus and the background winds can lead to large vector wind differences and hence flagging. The synoptic-dependent background errors (Parrett, 1992), currently under test, should improve matters by increasing the background errors in jetstream regions and consequently relax the quality control in these areas somewhat.

3.5 NESDIS 500km satellite soundings (SATEMs)

Figure 9 shows the number of satems rejected in each layer during October 1992. About 80% of tropospheric layers (below 100mb) and 45% of stratospheric layers had a prior reject flag. These flags are set for the whole sounding where it is co-located with either a LASS observation (before they were rejected from 14th October) or a 120km satem (accounting for the increase in tropospheric flags compared with October 1991 (~30%)). Tropospheric layers only are rejected over model land points, whereas in October 1991 all layers were rejected. The bottom layer is also rejected north of 30°S, and the top satem layer (7-3mb) is permanently rejected, because background heights are not available for 3mb.

Of the remaining satems, ~25% fail the tropospheric stability check, which compares the stability of the sounding below 300mb with that of the background. There are fewer stability flags in the bottom layer, indicating that the majority are in the northern hemisphere.

The multi-level check, which basicly rejects all layers above or below 100mb if at least one of these layers is flagged or two layers are suspect (PGE > 0.3), rejects ~5% of stratospheric layers but very few tropospheric layers. Likely tropospheric layers have probably already been flagged by the stability check. There are very few remaining layers that were rejected by the

background check, except high in the stratosphere where a model temperature bias led to ~20% of the 10-7mb layer being flagged. The layers next to the surface are flagged if they are suspect, as is the layer 100-70mb if all layers below 100mb are flagged; these account for the 'other' flags.

3.6 Radiosondes

The number of radiosonde observations at each model level in October 1992 was approximately the same as in October 1991. The highest number was again at level 5 (~800mb), at just above 60000, falling steadily to ~50000 at level 14 (~150mb) and then falling off more rapidly to zero at level 19.

Figure 10 shows the percentages of sonde winds, temperatures and relative humidities rejected at each model level in October 1992. Less than 1% of sonde winds were flagged at any level (Figure 10(a)), which is down on October 1991 when over 1.5% were flagged at levels 12 and 13. This is probably due mainly to the change on 9th June 1992 to omit levels with large PGEs from the vertical averaging, and it probably represents an improvement. Most of the permanent (prior) rejects were in the southern hemisphere, accounting for 2% of sonde winds south of 30°S. There was a small percentage of winds rejected by CFO, but most of the rejections were by the background check. These peak at level 11 (~300mb) at 0.7% *(0.9%)* and account for at least 0.5% of winds between 500mb and 150mb, near the level of the jetstream. The remaining small percentage of flags are buddy check flags, which peak at just 0.03% at ~350mb.

Figure 10(b) shows that there were more temperatures flagged than winds, but most were prior rejects, consisting mainly of Indian stations which are all permanently rejected. The majority of the remaining rejections were background flags, which peak at level 1 (presumably due to boundary layer effects) and again at level 16 in the stratosphere. Throughout most of the troposphere (above the boundary layer) only 0.2-0.3% of sonde temperatures were flagged by the background check, which compares with 0.5-0.6% for October 1991 - again probably the result of the change to the vertical averaging. There were few buddy check flags and most were

near the surface - still less than 0.2% of sonde temperatures at level 1, compared to 2.0% of temperatures with background flags.

There were few relative humidities rejected below about 600mb (~1%) and most of these were background flags. Above 600mb, the proportion of humidities with a prior flag increases steadily to 100% at ~200mb; these are humidities with associated temperatures below -40°C, which are given a permanent reject flag. [N.B. After 13th October 1992 humidity observations with temperatures below -40°C had a permanent reject flag set, but no final flag (and therefore were used in the assimilation) due to an error in the quality control.] The 'other' flags, mostly between ~600mb and ~250mb, are where a relative humidity with associated temperature below -40°C has been used to interpolate to produce a humidity at the model level concerned (where the temperature is above -40°C); the change on 13th October stopped these flags being set.

4. Summary

Apart from satellite data, the percentages of observations flagged by the quality control scheme mostly decreased during 1992. Since it was generally perceived (especially by CFO forecasters) that the QC tended to flag too many observations (particularly radiosonde, aircraft and ship winds), this represents an overall improvement.

The changes that seem to have had the most beneficial impact were the following (in chronological order):

(i) setting the $PGE_{(location)} = 0$ for GOES cloud-track winds, on 19th November 1991;

(ii) reducing the 'top-hat' function for ship winds, on 10th December 1991;

(iii) the large increase in automated aircraft reports, on 10th December 1991;

(iv) the change to the quality control of radiosondes, to omit levels with high PGEs from the vertical averaging, on 9th June 1992;

(v) using reported P_{msl} below 500m, instead of calculating P_{msl} from reported station level pressure, on 7th July 1992; and

(vi) enhancing the background errors near to bogus and supported observations, on 1st December 1992.

5. References

Ingleby, N B 1991 (I91): Tuning and performance of the atmospheric quality control.
Short-range Forecasting Technical Report No. 6.

Ingleby, N B and Parrett, C A 1991: Quality control of atmospheric data. UMDP No. 32.

Parrett, C A 1992: Background errors for the quality control and assimilation of atmospheric observations in the Unified Model - the situation in July 1992.
Short Range Forecasting Technical Report No. 22.

Wright, J D 1993: The effect of using synop reported mean sea level pressure on quality control decisions.
Central Forecasting Monitoring Note No. 14.

Acknowledgements

Thanks are due to Bruce Ingleby for most of the original SAS programs and for helpful comments on the report.

Appendix A - Operational changes that may have affected the flagging of observations

19/11/91 SONDE/BOGUS: RH PGE reduced to 0.015 (from 0.05) and RH errors reset - σ_o=10%, σ_b=12% below 850mb with transition to 13% and 20% respectively at 300mb; changes to sonde wind and temperature error profiles and Hawson corrections.

SATOB: GOES PGE(location)=0.0 below 800mb, =0.04 above.

SATEM: relax qc above 10mb - multiply PGE by 0.2 and error variance by 2, and removed 'Part C' check.

SURFACE: rejection/correction list updated for ship and drifter pressures and winds.

26/11 - 29/11/92 SATOB: Meteosat 5 used instead of Meteosat 4.

4/12/91 AIREP: AMDARs received from Australia and used in model.

10/12/91 SONDE: rejection list updated for winds and temperatures.

SURFACE: wind tophat (k) reduced from 0.0018 to 0.0010; rejection/correction list updated for ship and drifter pressures and winds.

23/12/91 AIREP: ASDARs and AMDARs given permanent reject flag (also flagged over North Atlantic 21st-23rd) - after 500 amdars with the same position (62N 45W) produced a spurious cold pool on 18th Dec.

31/12/91 - 3/01/92 SURFACE: wrong data extracted for 00Z runs and flagged by CFO; bug in observation processing (obs proc) corrected on 3/1/92.

8/01 - 15/01/92 SATEM: no NOAA12 data - HIRS instrument problem.

9/01/92 AIREP: aireps over mainland USA rejected.

SATOB: new satellite callsigns rejected, eg INSAT.

16/01/92 UM/SATEM: an error in vertical interpolation of satellite soundings in the Unified Model was corrected.

22/01/92 SONDE: temperature quality control relaxed north of 40°N and above 100mb (error variance multiplied by 9 (FIX)) - a warm bias in the model had caused flagging of sonde temperatures over W Europe and N Atlantic.

4/02/92 SONDE: reduced multiplicative factor in T-FIX to 4.

AIREP: permanent reject on ASDARs and AMDARs removed.

BOGUS: reposition bogus included.

SURFACE: rejection/correction list updated for ship and drifter pressures and winds.

SATEM: used over land above 100mb everywhere, previously only used over Antarctica;
obs errors for partly cloudy and cloudy soundings slightly increased (decreased) below (above) 100mb.

5/02/92 SATEM: correction to ACOBS program setting up Part C reports on their own.

11/02/92 U.M.: version change - 2.3 to 2.4.

11/02 - 25/02/92 SATOB: Meteosat 5 produced winds while Meteosat 4 was being decontaminated.

12/02/92 SATOB: new wind retrieval algorithm for GOES - better height assignment.

15/02/92 AIREP: re-transmitted aireps from Carswell now discarded.

18/02/92 SAT120: 120km satems used in global assimilation.

3/03/92 SATEM/SAT120/LASS: bug in obs processing corrected - previously some obs over sea not used and some obs over land used.

SAT120: sat120 data used in limited area assimilation.

10/03/92 SONDE: included representivity error for unaveraged radiosonde temperatures.

SURFACE: rejection/correction list updated for ship and drifter pressures and winds.

24/03/92 UM: vertical smoothing of winds in tropics 500-150mb.

31/03/92 SONDE: included sonde-sonde buddy check (T and V).

SURFACE: allow for greater number of drifters.

7/04/92 UM: revised long-wave radiation to reduce cold bias in upper troposphere.

5/05/92 SONDE: temperature-FIX removed (in since 22/1).

BOGUS: not used within one degree of LAM boundary.

LASS: NOAA 12 data used in addition to NOAA 11 data.

12/05/92 U.M.: version change - 2.4 to 2.5.

SURFACE: rejection/correction list updated for ship and drifter pressures and winds.

9/06/92 AIREP: block rejection of aireps over USA removed and replaced by rejection of reports from certain airlines.

SONDE: improved vertical averaging, by omitting standard and significant levels with high PGEs;

relaxed quality control of RH.

16/06/92 SURFACE: rejection/correction list updated for ship and drifter pressures and winds.

7/07/92 SURFACE: reported P_{msl} used for stations below 500m.

10/07/92 BOGUS: obs proc correction to not reject bogus RH.

4/08/92 SATEM: minor bug in obs proc corrected (in since 16/6); correction to LAM extraction; satellite sounding quality control re-arranged.

11/08/92 U.M.: version change - 2.5 to 2.6.

1/09 - 7/09/92 SONDE: removed prior reject of RH when T < -40°C.
AIREP: duplicate check introduced.

7/09/92 SATEM: wrong units for PWC (MDB change).

8/09 - 22/09/92 SATOB: winds from Meteosat5 instead of Meteosat 4.

29/09/92 SURFACE: CFO allowed to apply pressure corrections again, after being ignored since 7/7/92.

6/10/92 U.M.: changed from 20 to 19 levels; error in assimilation (HORINF) corrected.

10/10/92 SATOB: receipt of winds from INSAT stopped.

13/10/92 SONDE: coding errors corrected; removed prior rejection of RH when T < -40°C; rejection list updated.
SURFACE: rejection/correction list updated for ship and drifter pressures and winds; small error in obs processing corrected.
AIREP: duplicate check introduced; rejection list updated.
BOGUS: reposition bogus scheme extended to North Pacific.

14/10/92 LASS: CFO began rejecting all LASS, because of T-bias in model and feed-back through the LASS data.

16/10/92 LASS: permanent reject flag set for all LASS data.

24/10 - 2/11/92 SONDE: no Australian or New Zealand obs extracted.

27/10/92 U.M.: version change - 2.6 to 2.7 - corrected cold bias in output temperatures, except above 10mb.

2/11/92 SONDE: correction to obs processing to prevent failures.

3/11/92 SONDE/AIREP/SURFACE: small improvement to the buddy check (N_c^2 reduced from 625 to 225).
SONDE: correction to obs proc to ensure extraction of Australian and New Zealand radiosonde reports.

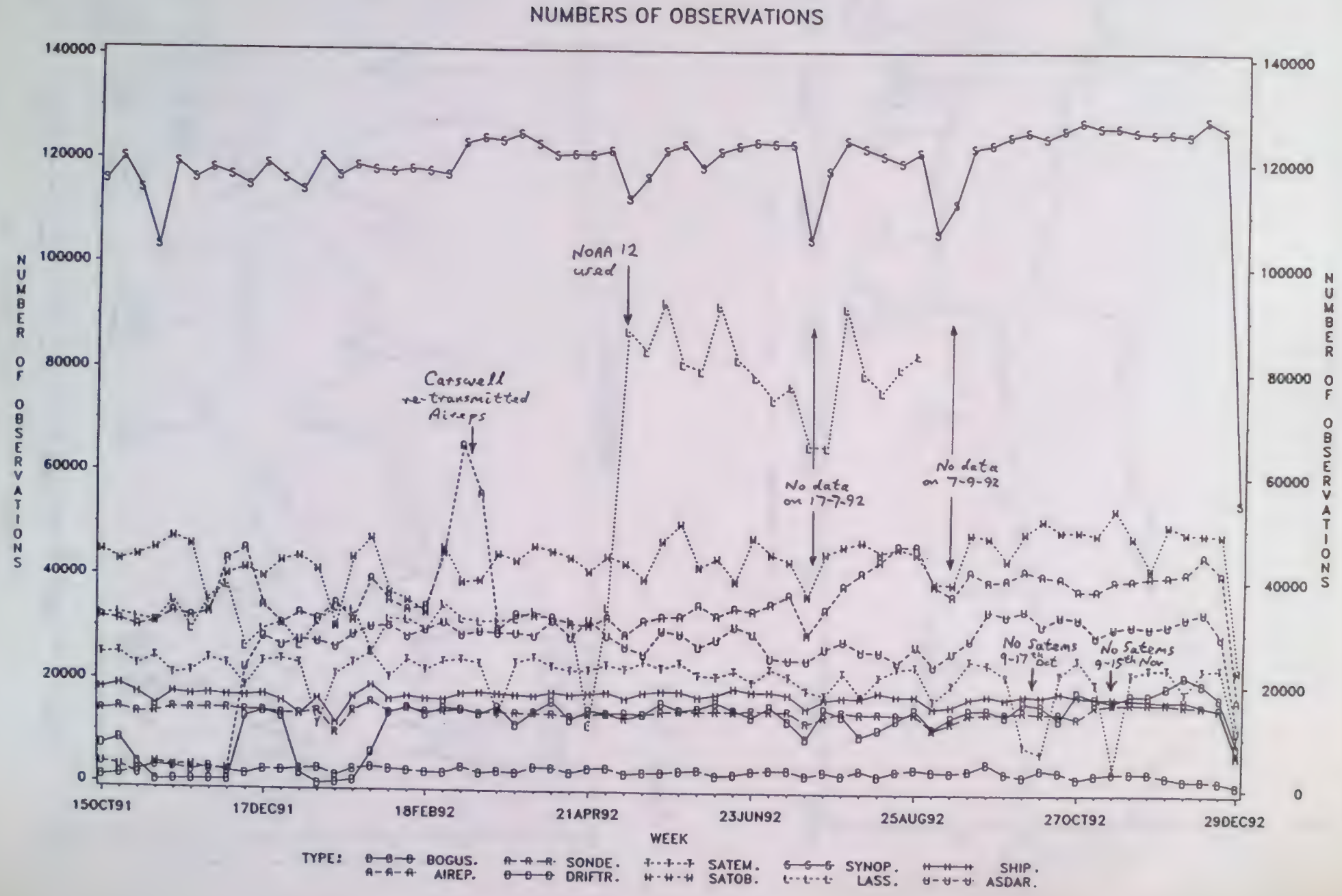
10/11/92 SURFACE: rejection/correction list updated for ship and drifter pressures and winds.

17/11/92 U.M. (2.7+): global assimilation tuned;
timesmoothing of adjustment velocities;
change from 4 adjustment steps to 3;
change to vertical interpolation to obtain output heights used by satellite sounding data.
[All changes temporarily removed 20th-25th.]

1/12/92 BOGUS/SUPPORTED: enhancement of background errors near to bogus and supported obs introduced, and multiplicative factor within the quality control reduced from 4 to 3 (times the total error variance).
SURFACE: BGE coefficients for P_{msl} and V_{10m} updated; observation errors for V_{10m} reduced from 2.0 to 1.7 ms^{-1} for ships, and tophat function for V_{10m} reduced from 0.0010 to 0.0002.
SONDE/SURFACE/AIREP: maximum number of buddies reduced by approximately a quarter (from 8-12 to 6-9).
SONDE: gross error checks included in obs processing step.
[All changes temporarily removed 2nd - 3rd.]

15/12/92 SURFACE: rejection/correction list updated for ship and drifter pressures and winds.

Figure 1.


NUMBERS OF OBSERVATIONS
NUMBER OF OBSERVATIONS
140000
120000
100000
80000
60000
40000
20000
0
NOAA 12 used
Carswell re-transmitted Aireps
No data on 17-7-92
No data on 7-9-92
No Satems 9-17th Oct
No Satems 9-15th Nov
15OCT91
17DEC91
18FEB92
21APR92
23JUN92
25AUG92
27OCT92
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WEEK
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AIREP. DRIFTR. SATOB. LASS. ASDAR.

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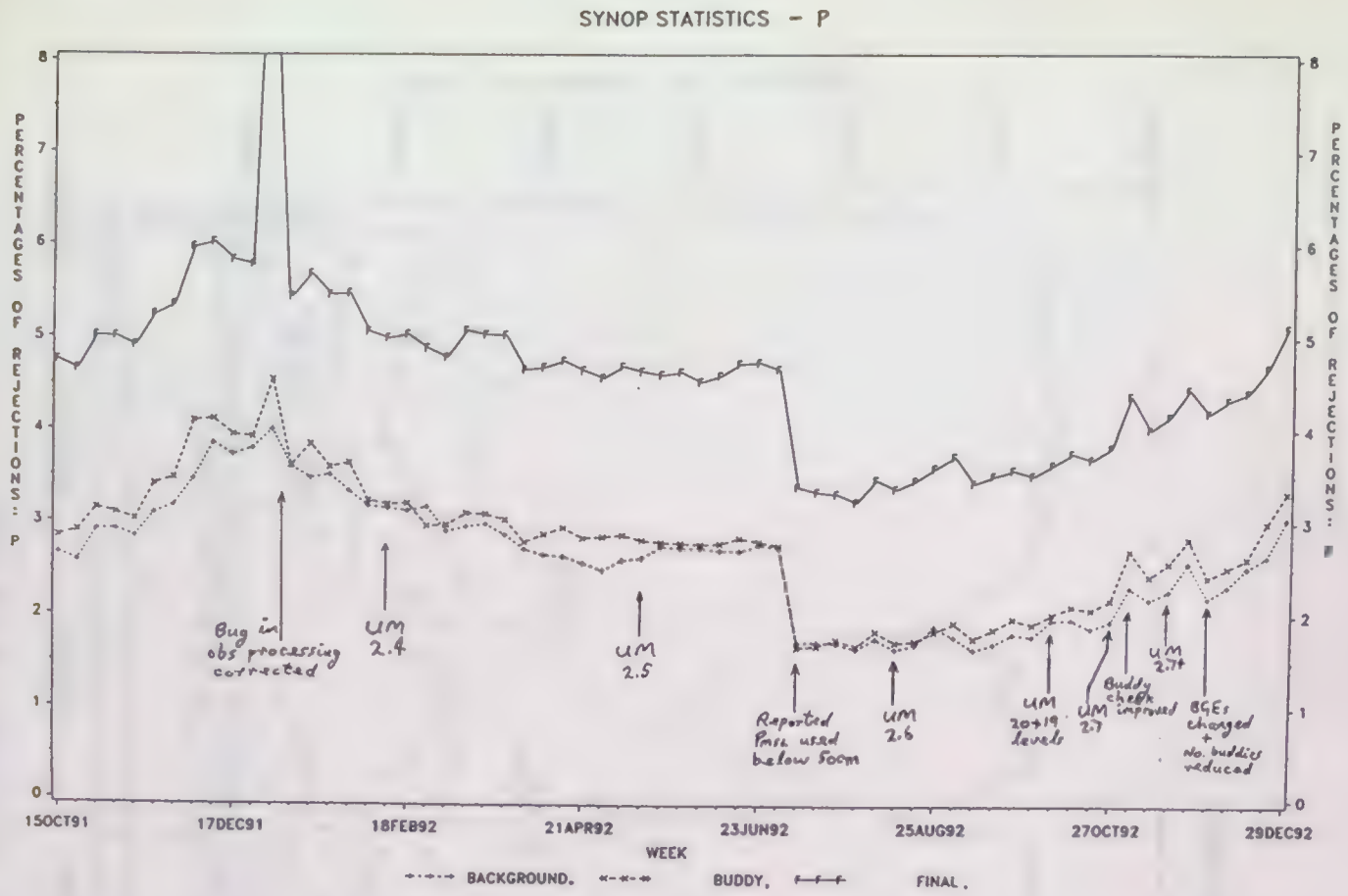

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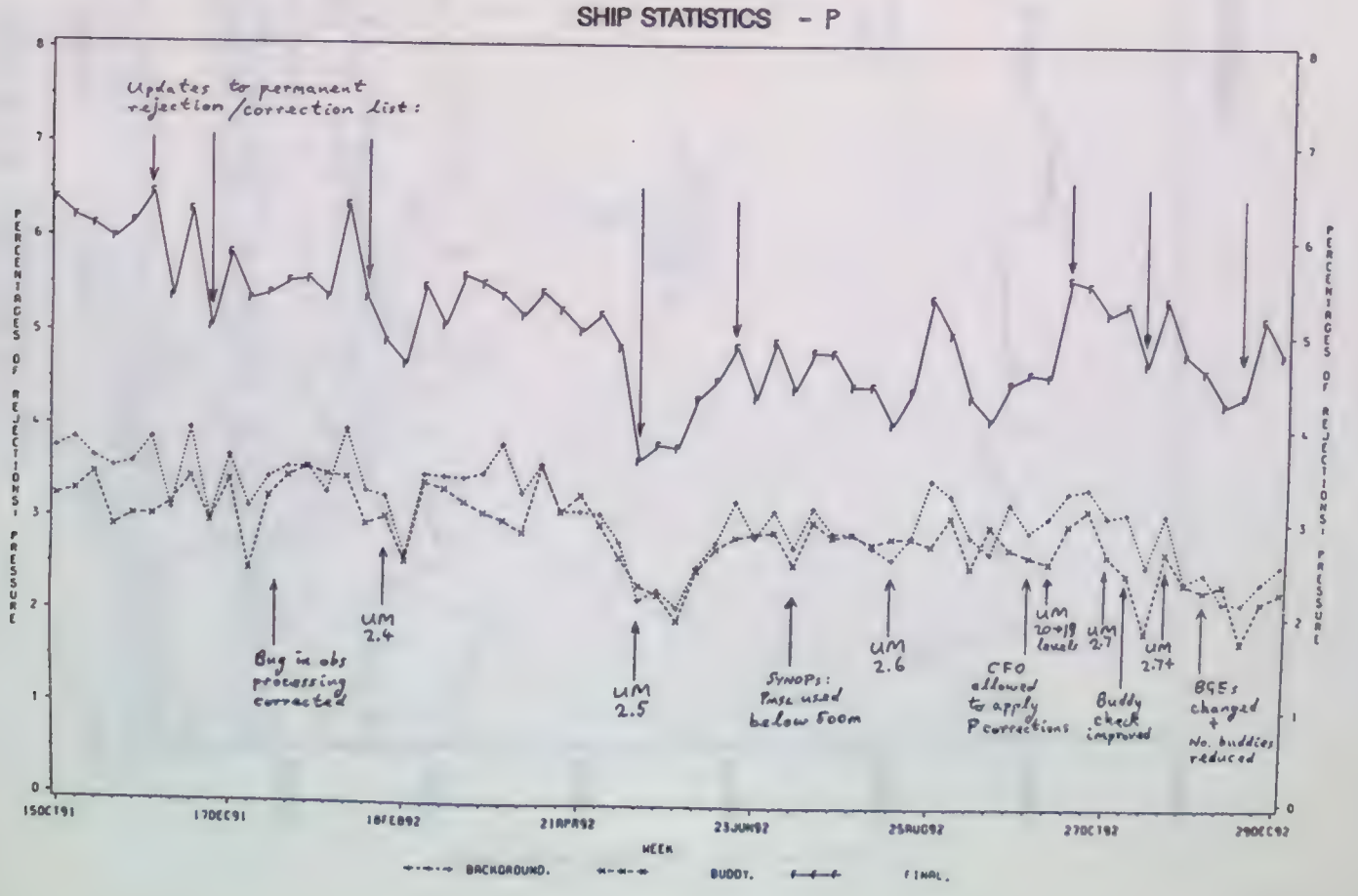

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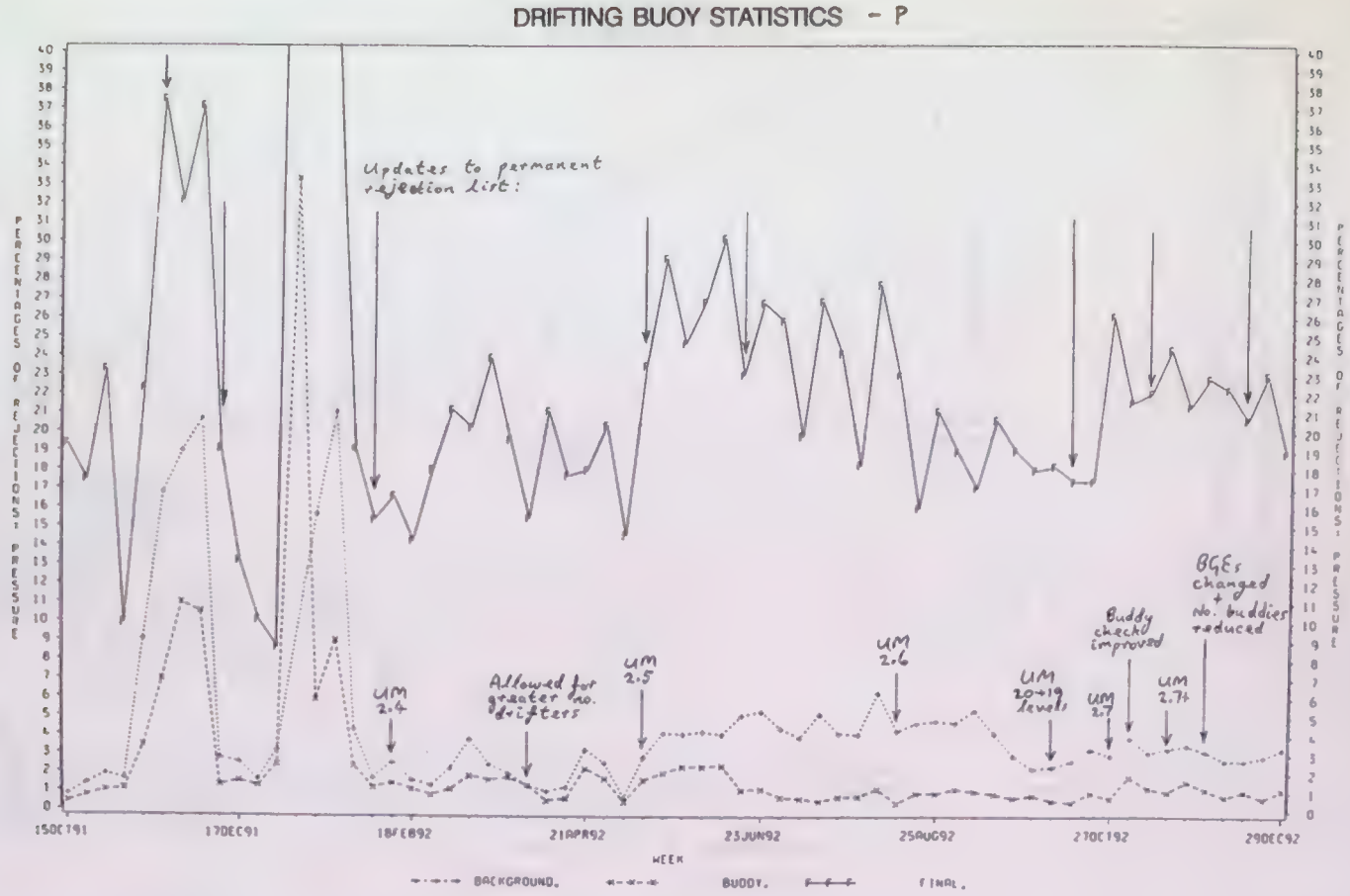

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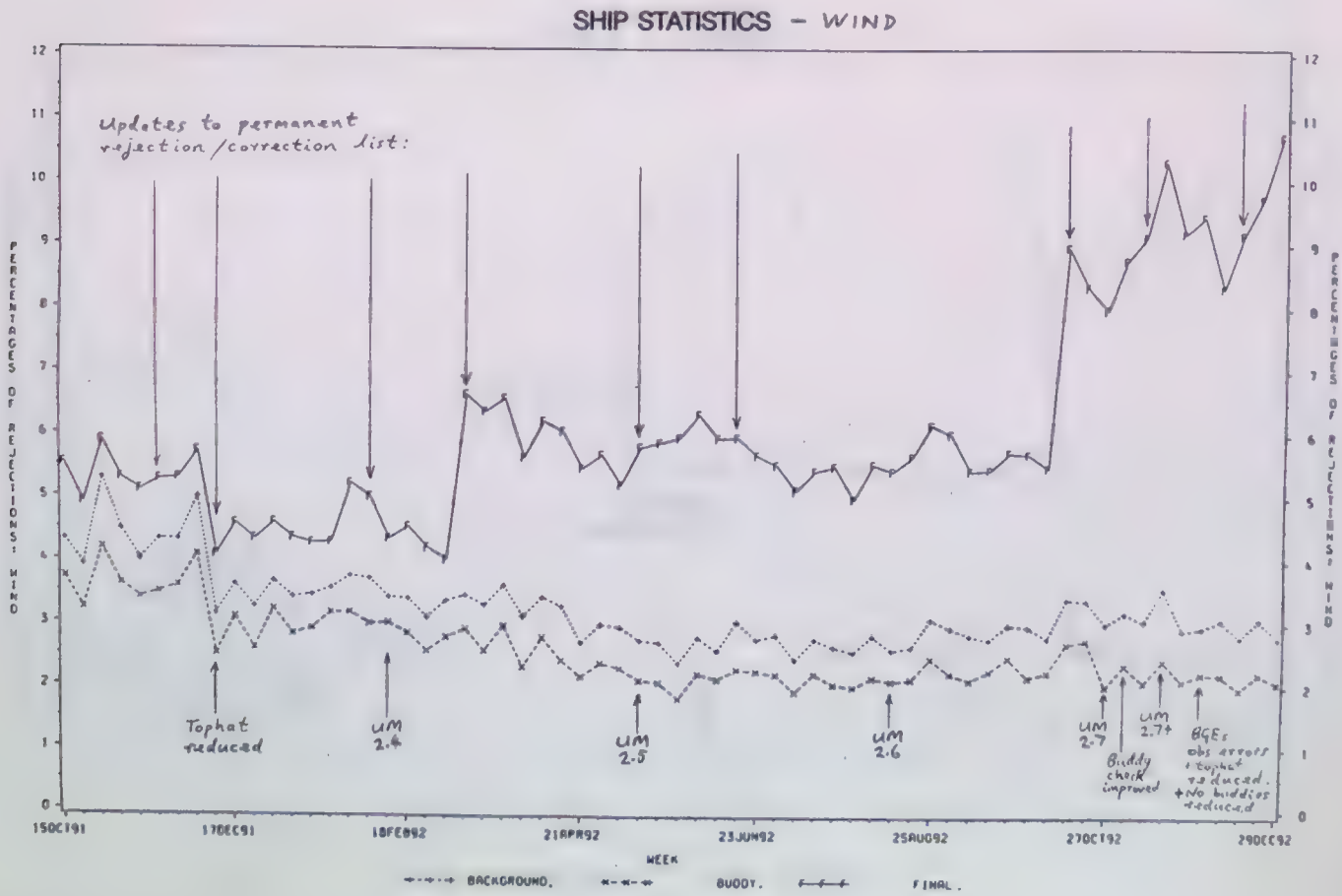

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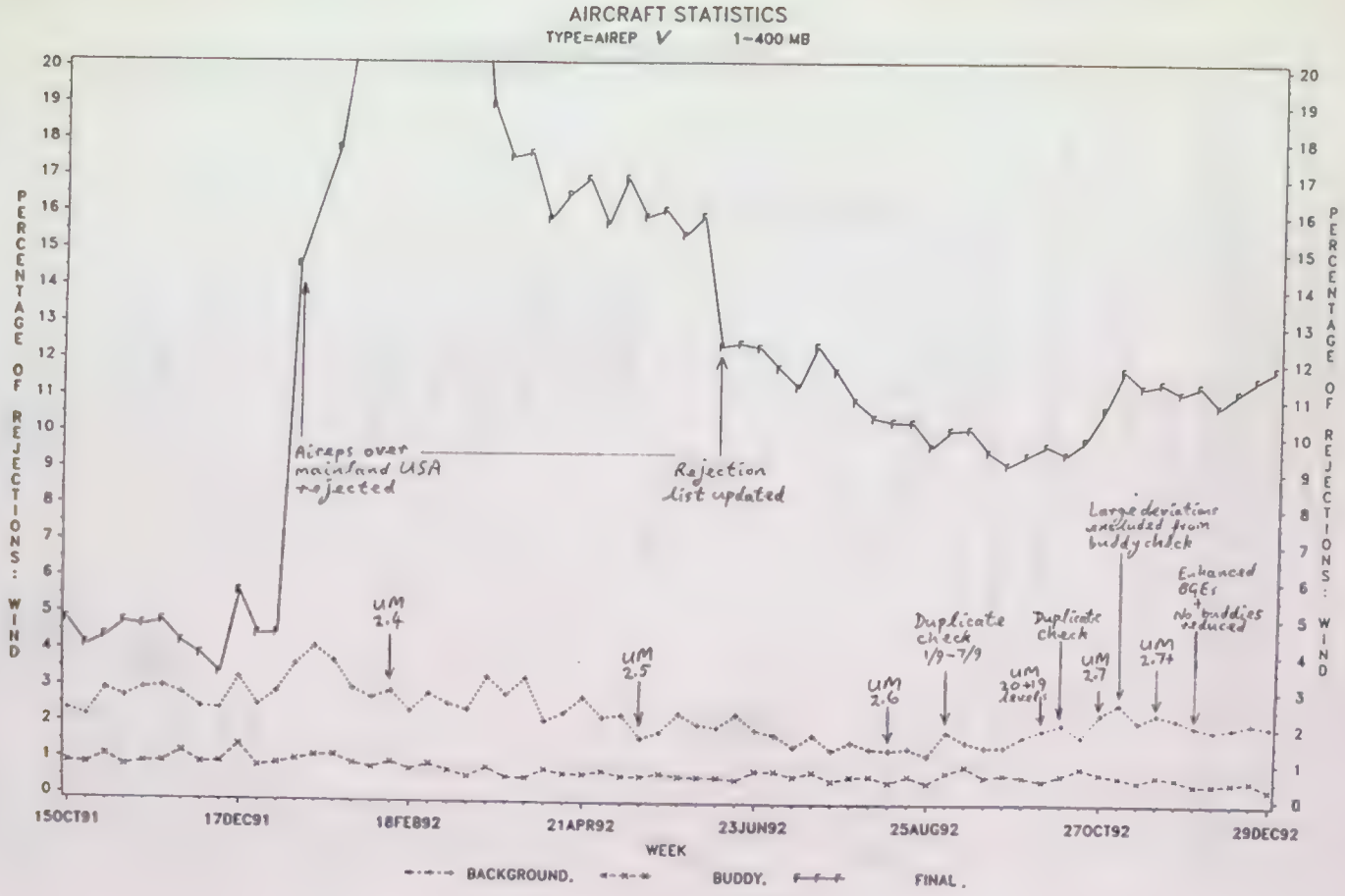

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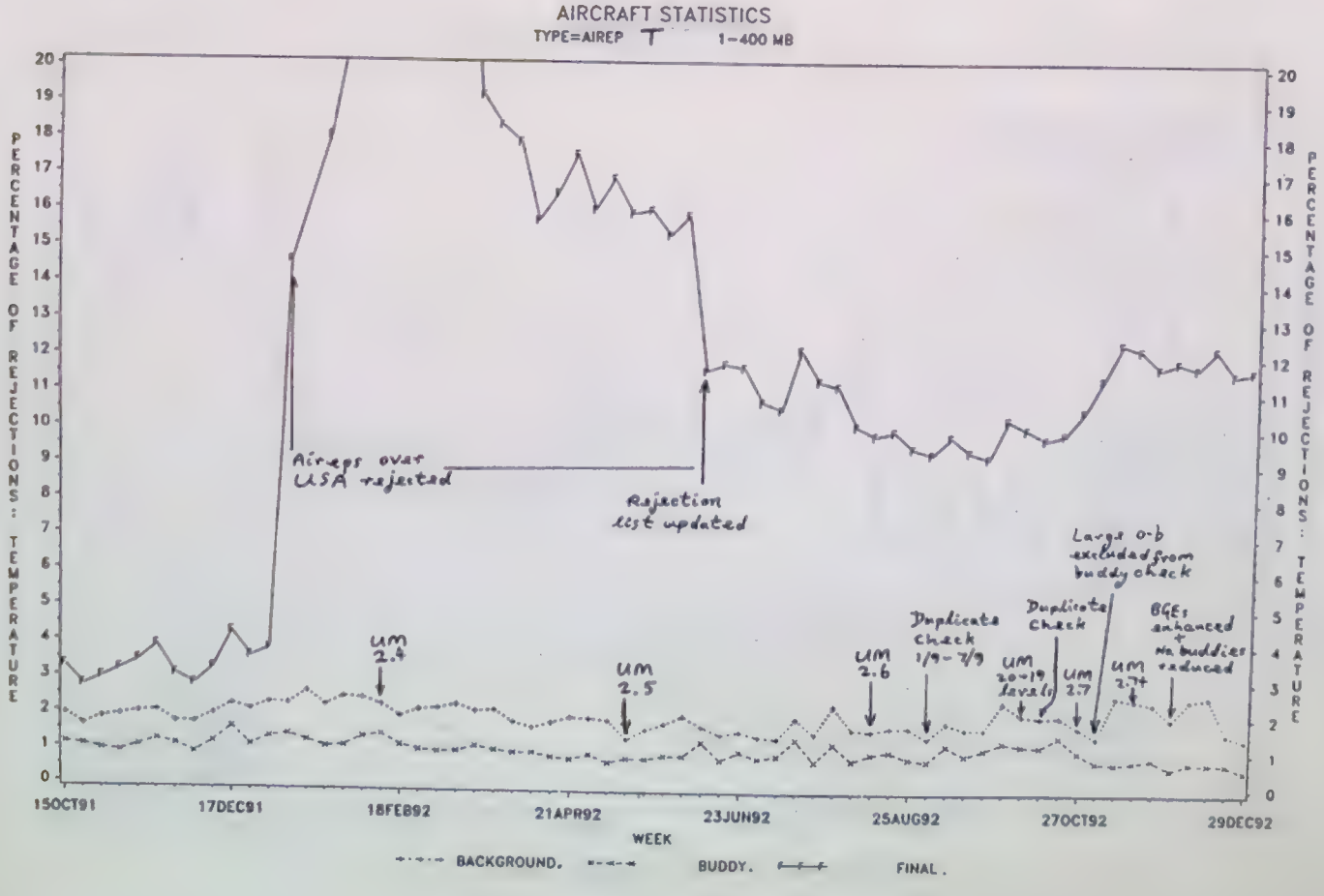

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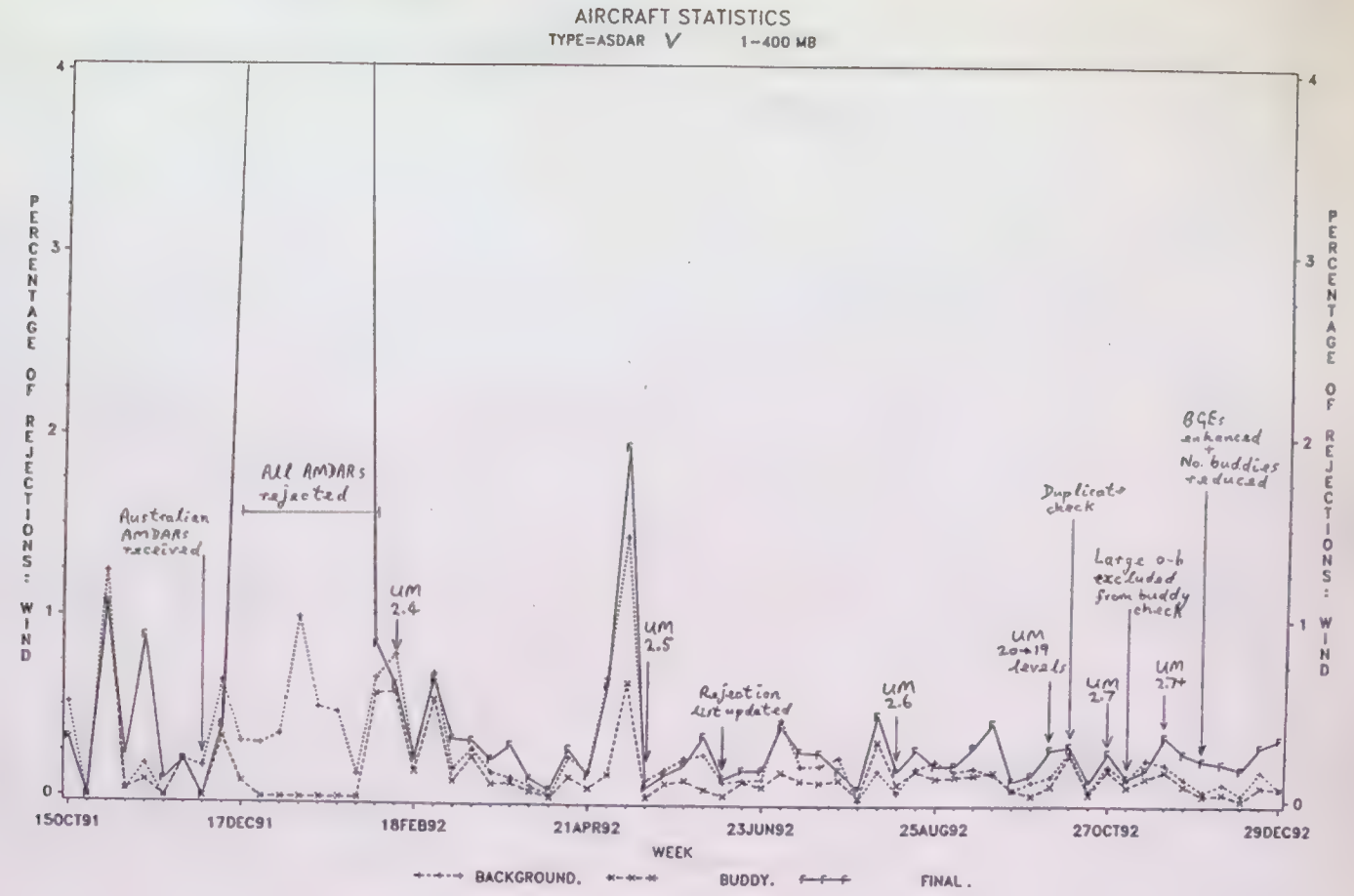

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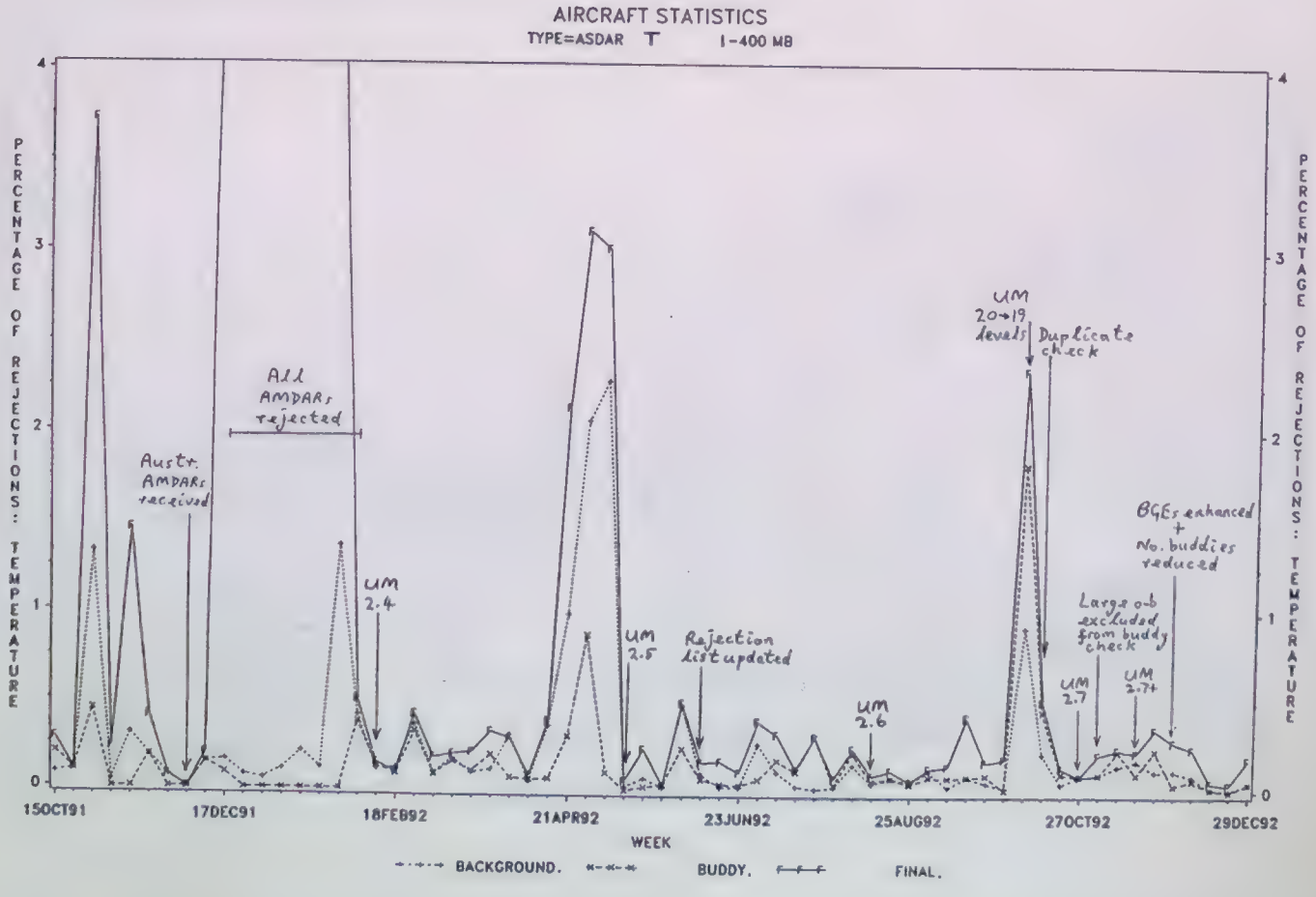
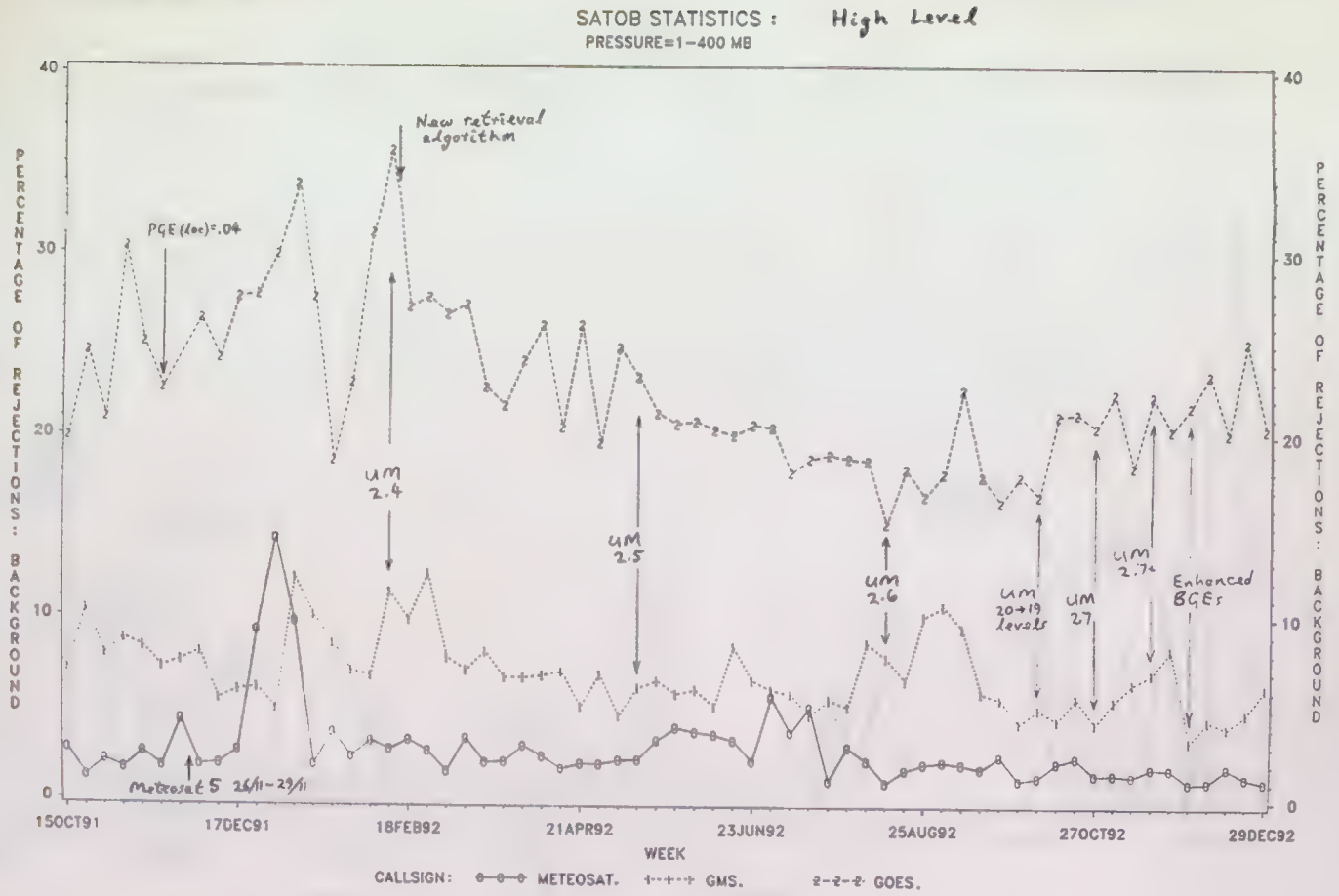


Figure 4 (a)



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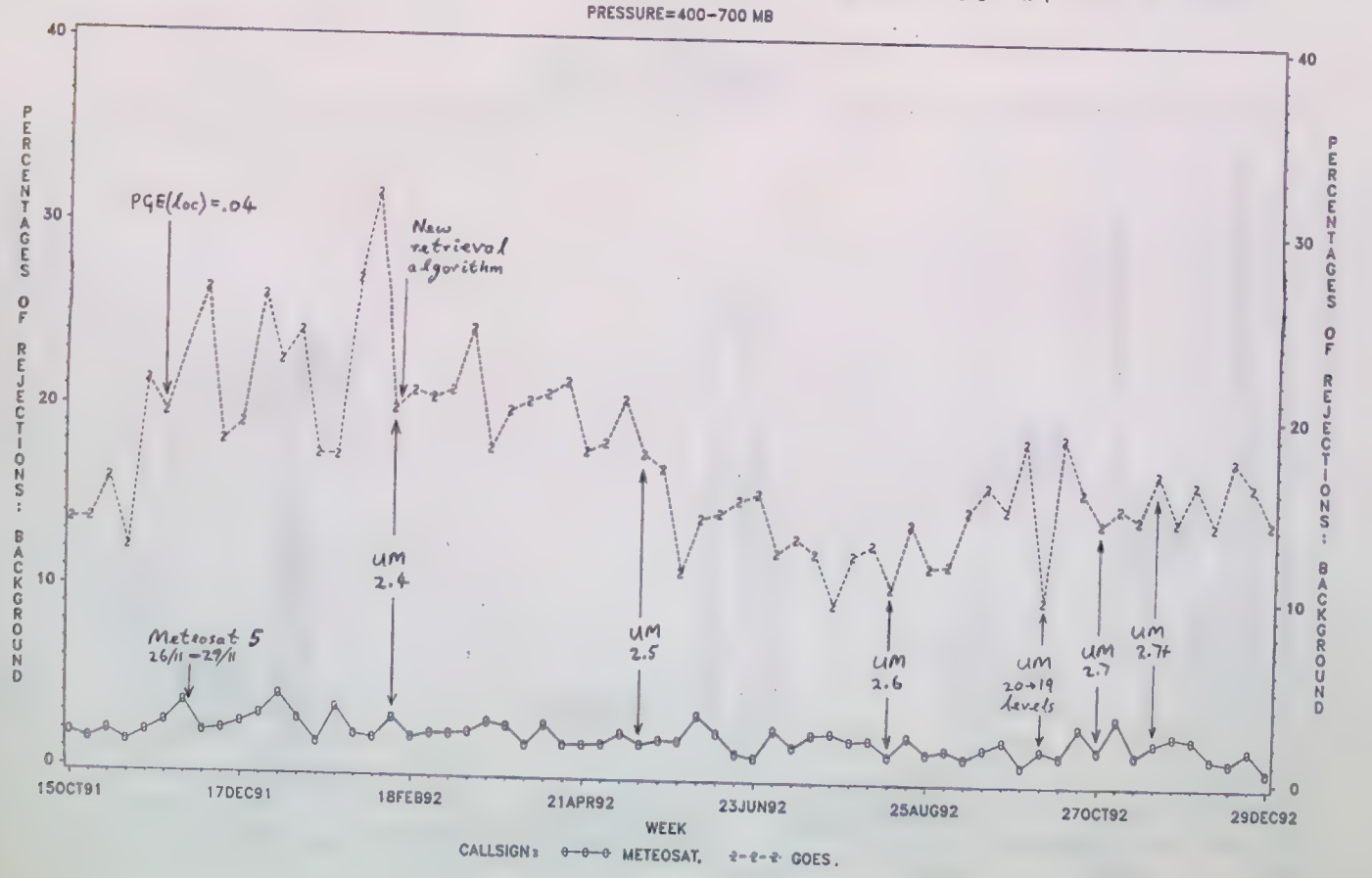

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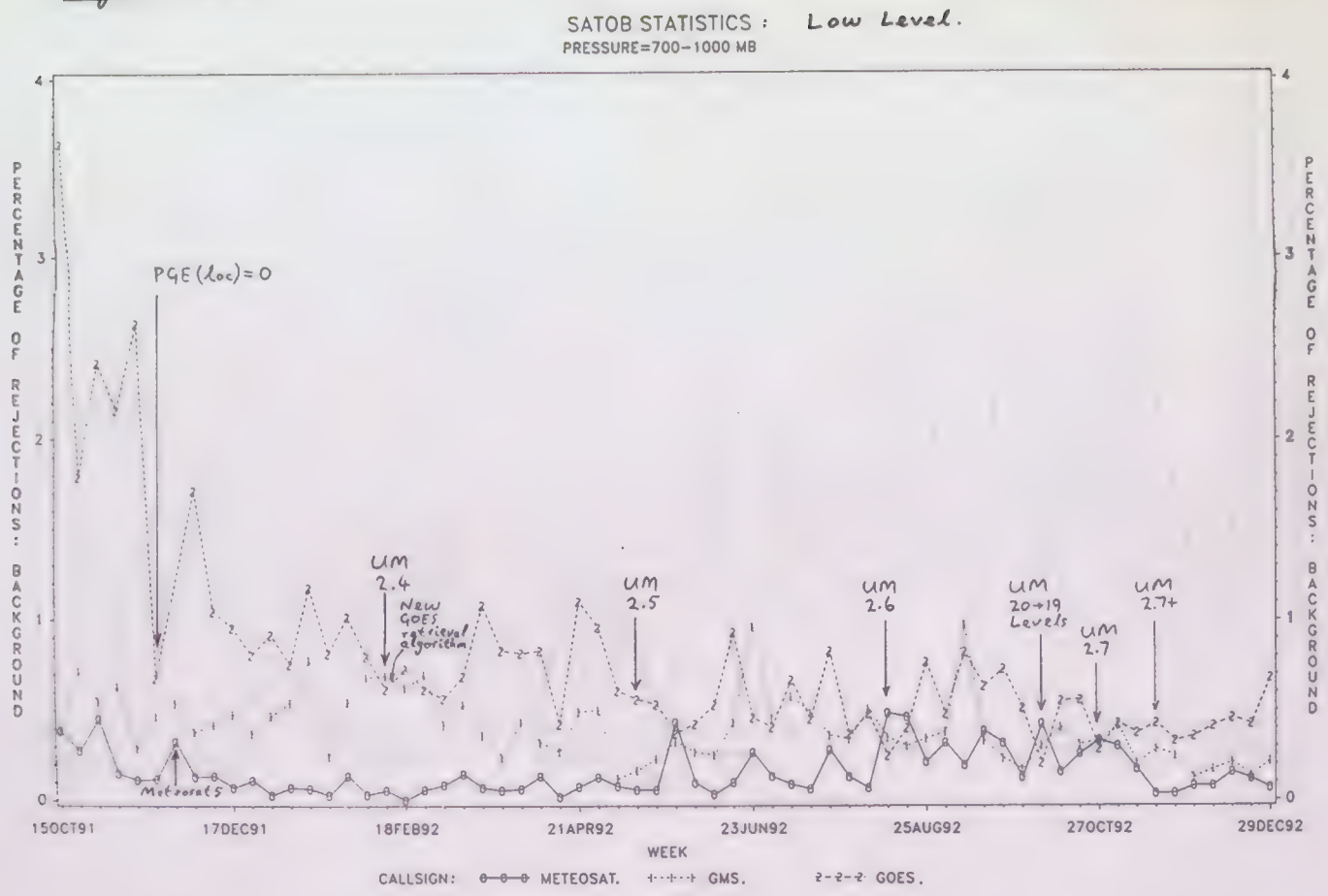
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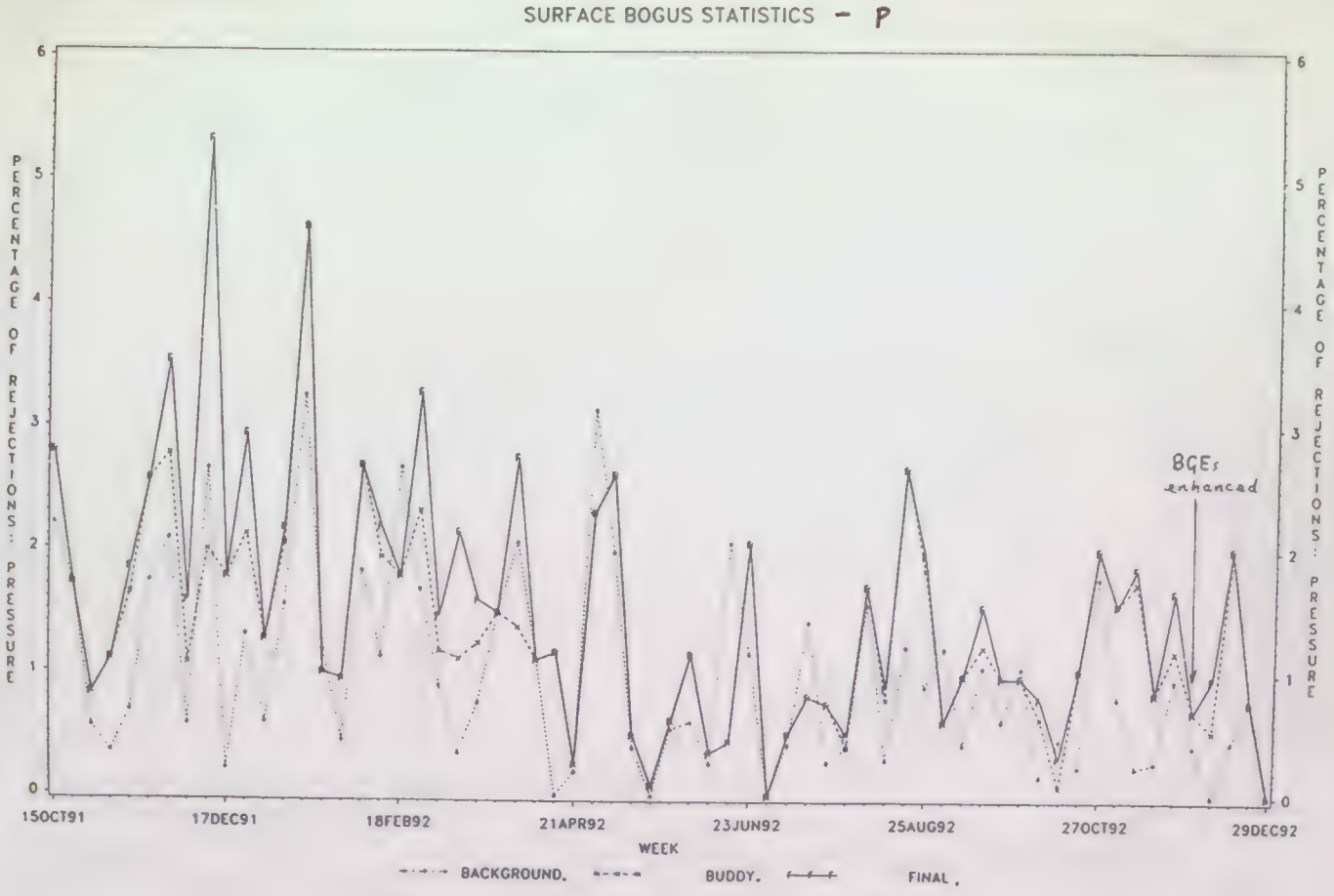
PRESSURE=700-1000 MB
PERCENTAGE OF REJECTIONS: BACKGROUND
PERCENTAGE OF REJECTIONS: BACKGROUND
PGE (loc) = 0
UM 2.4
New GOES retrieval algorithm
UM 2.5
UM 2.6
UM 20→19 Levels
UM 2.7
UM 2.7+
Meteosat 5
150CT91
17DEC91
18FEB92
21APR92
23JUN92
25AUG92
27OCT92
29DEC92
WEEK
CALLSIGN: METEOSAT. GMS. GOES.

Figure 5 (a)



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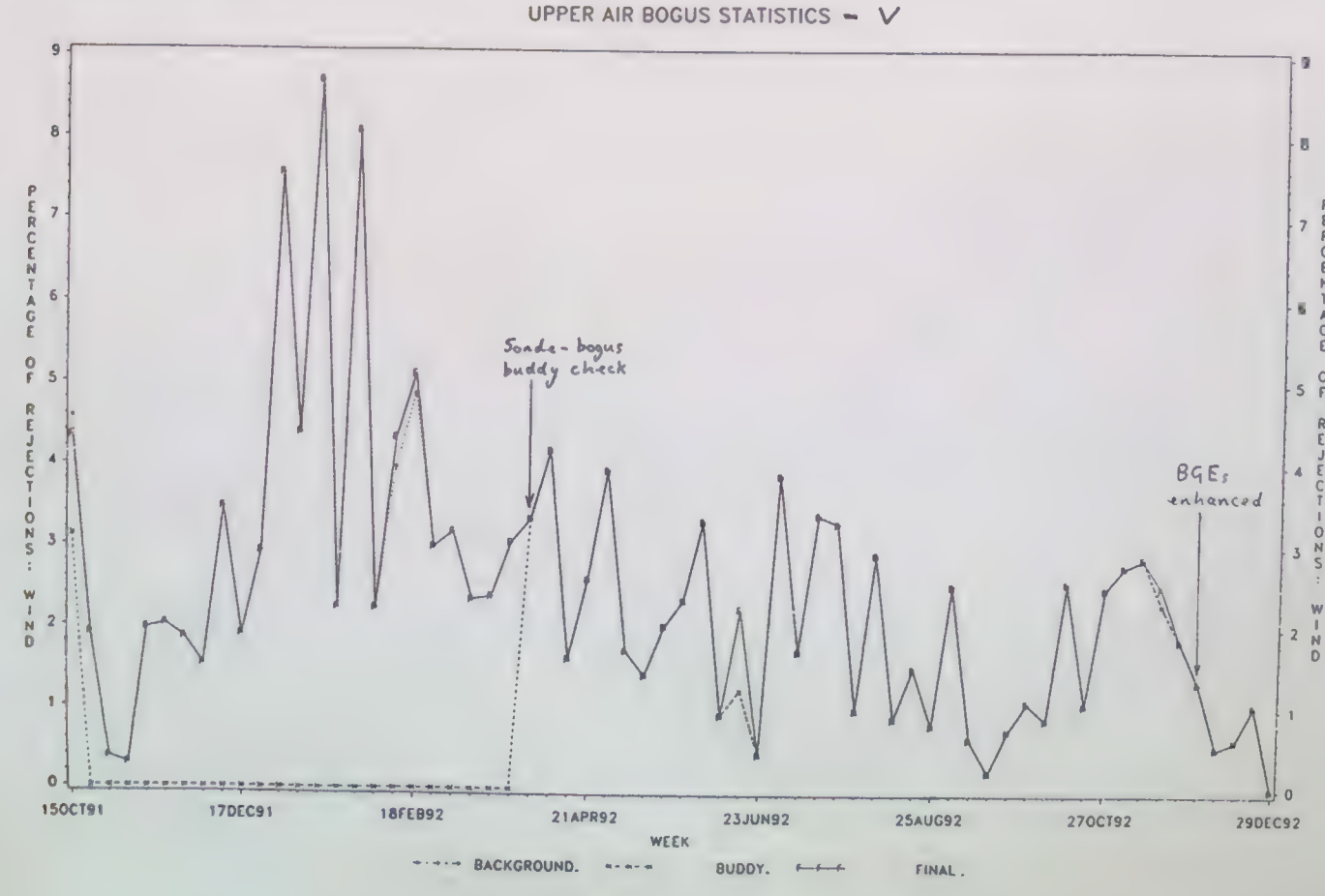


Figure 6.

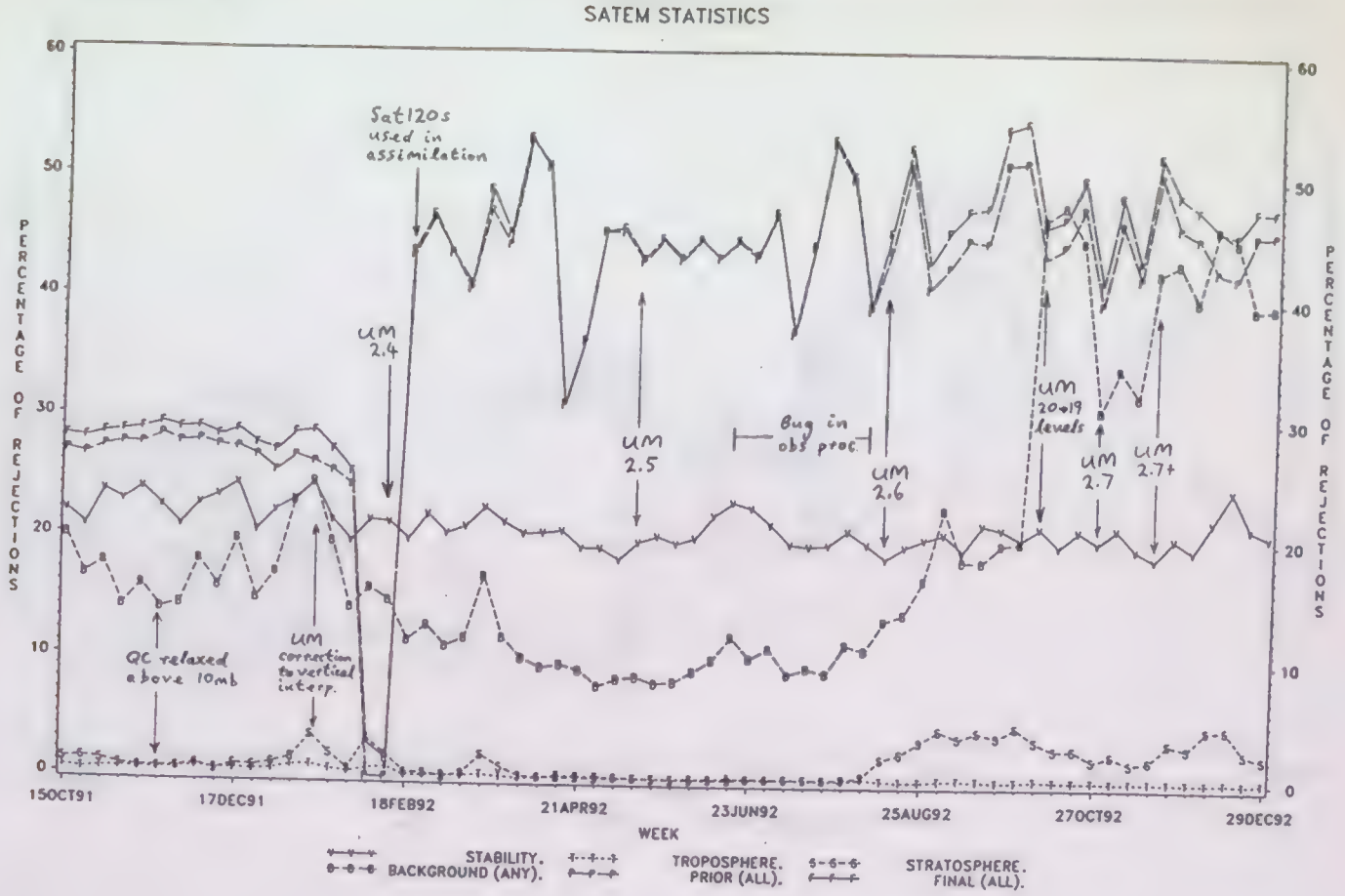


Figure 7.

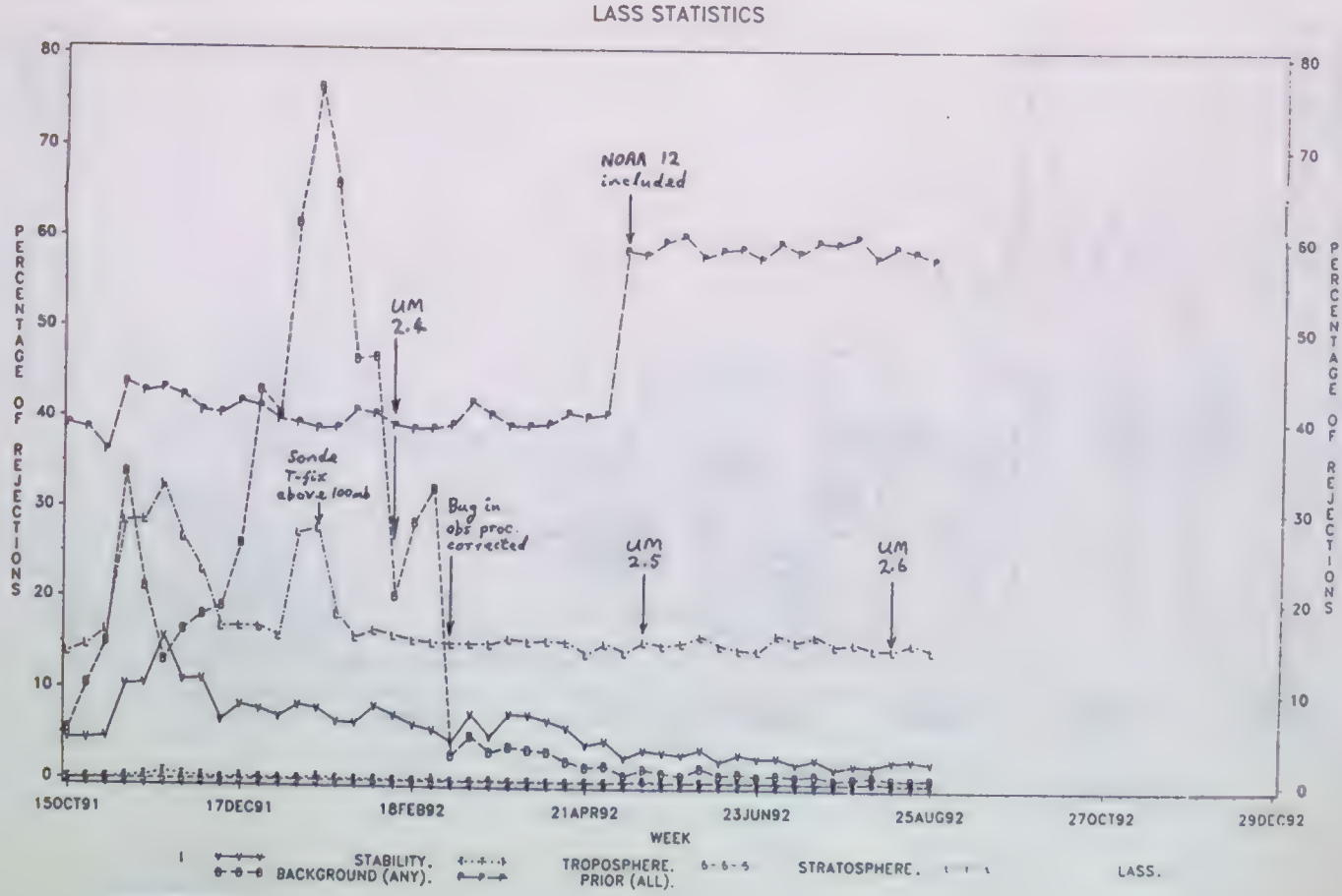
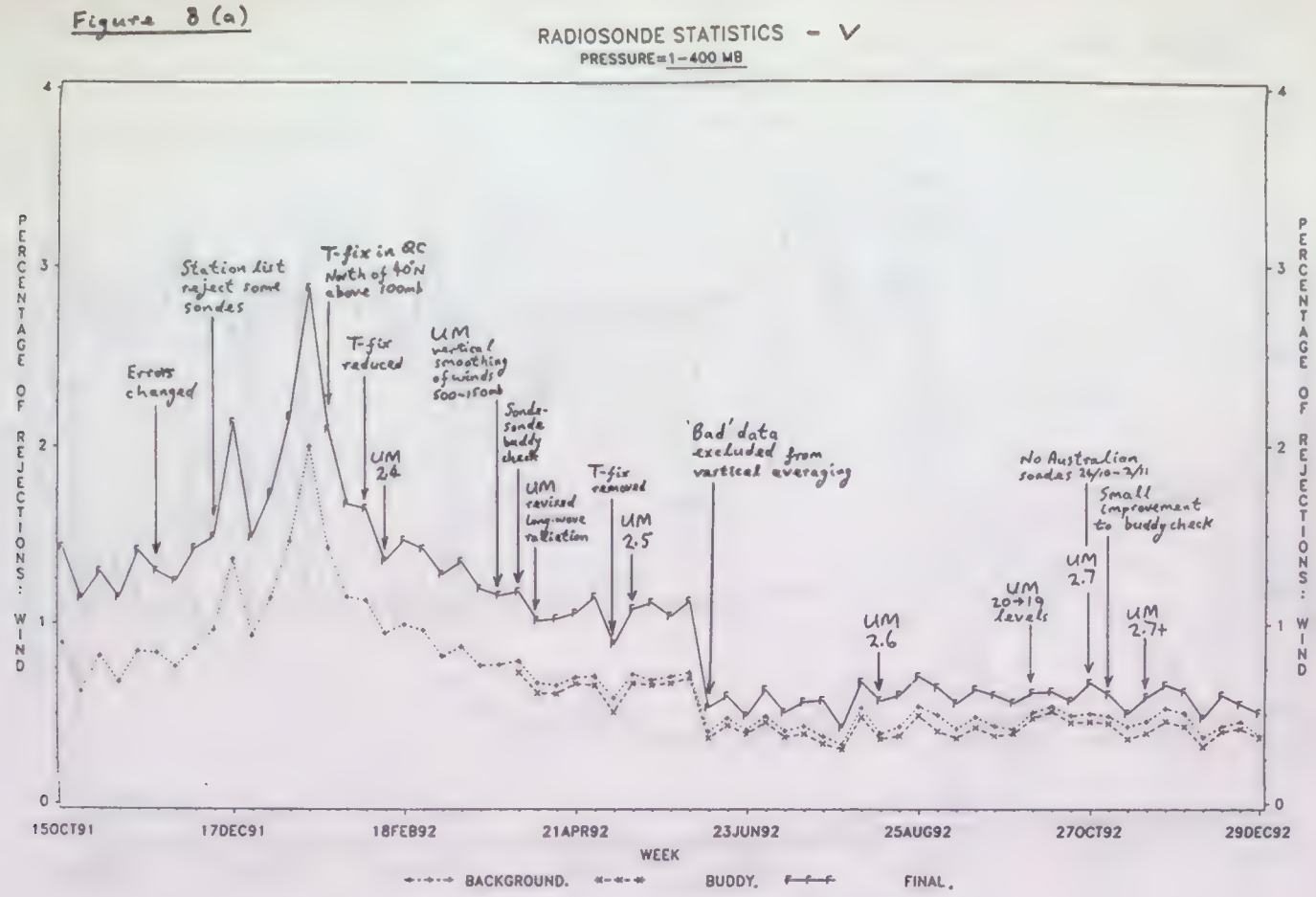


Figure 8 (a)



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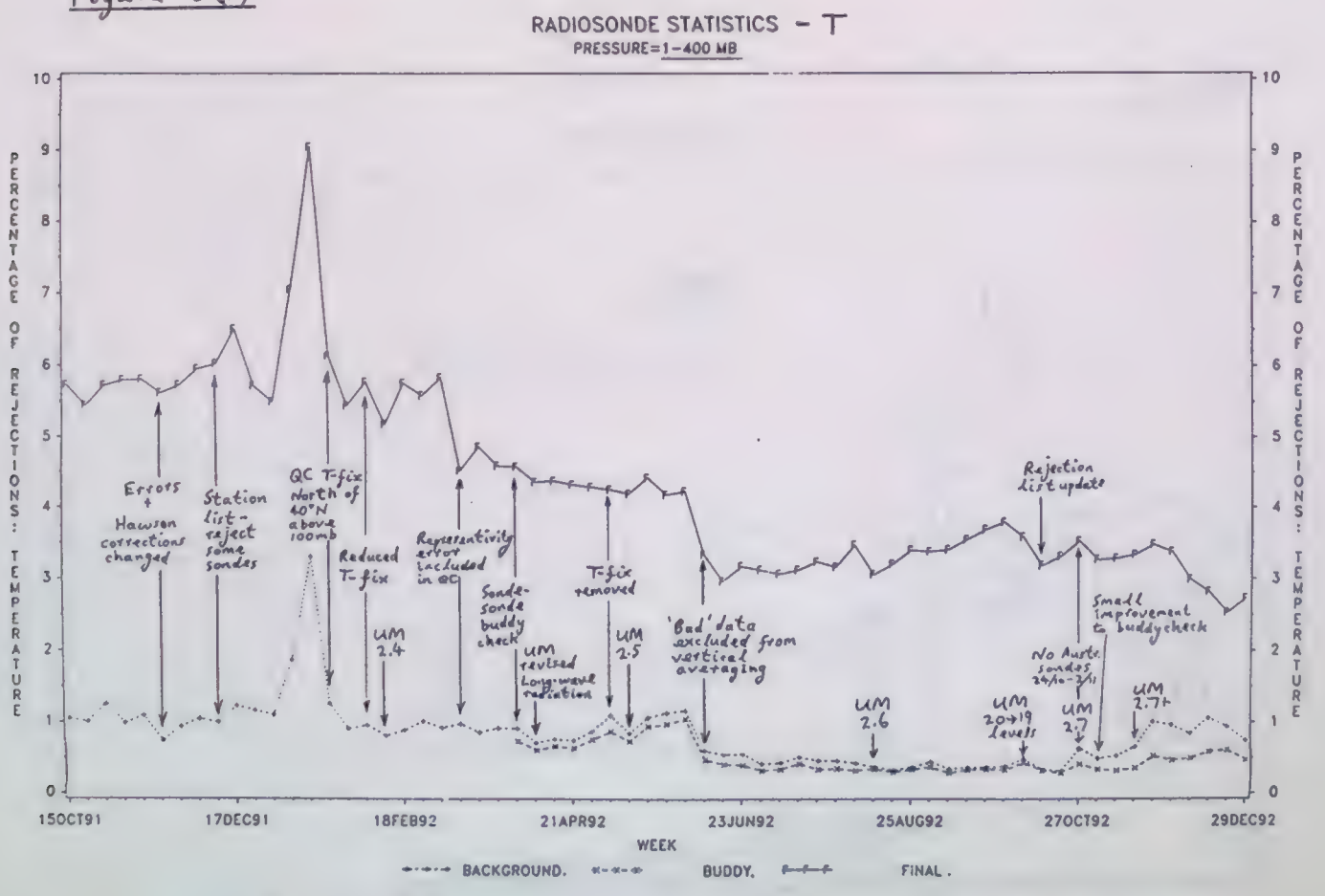

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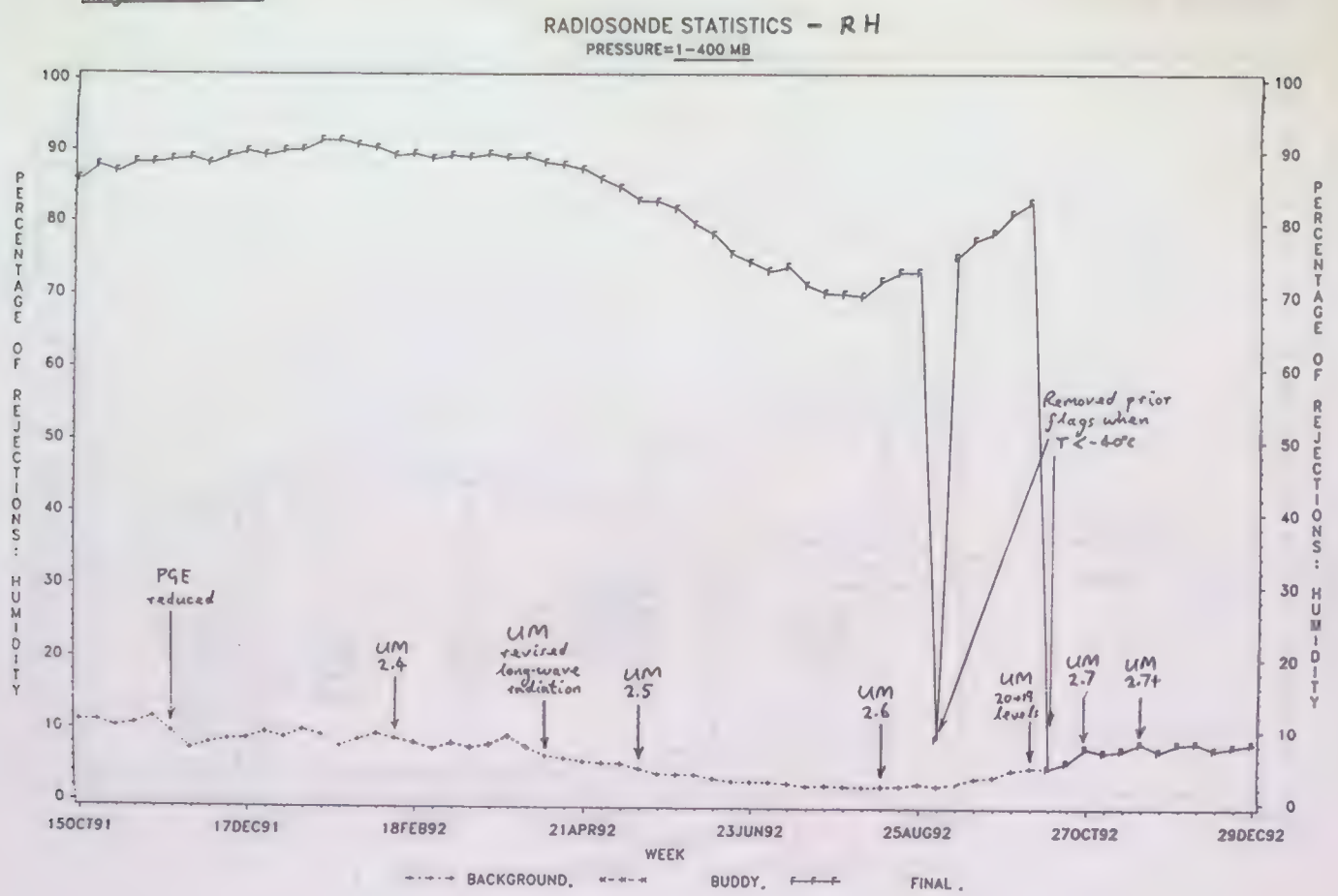

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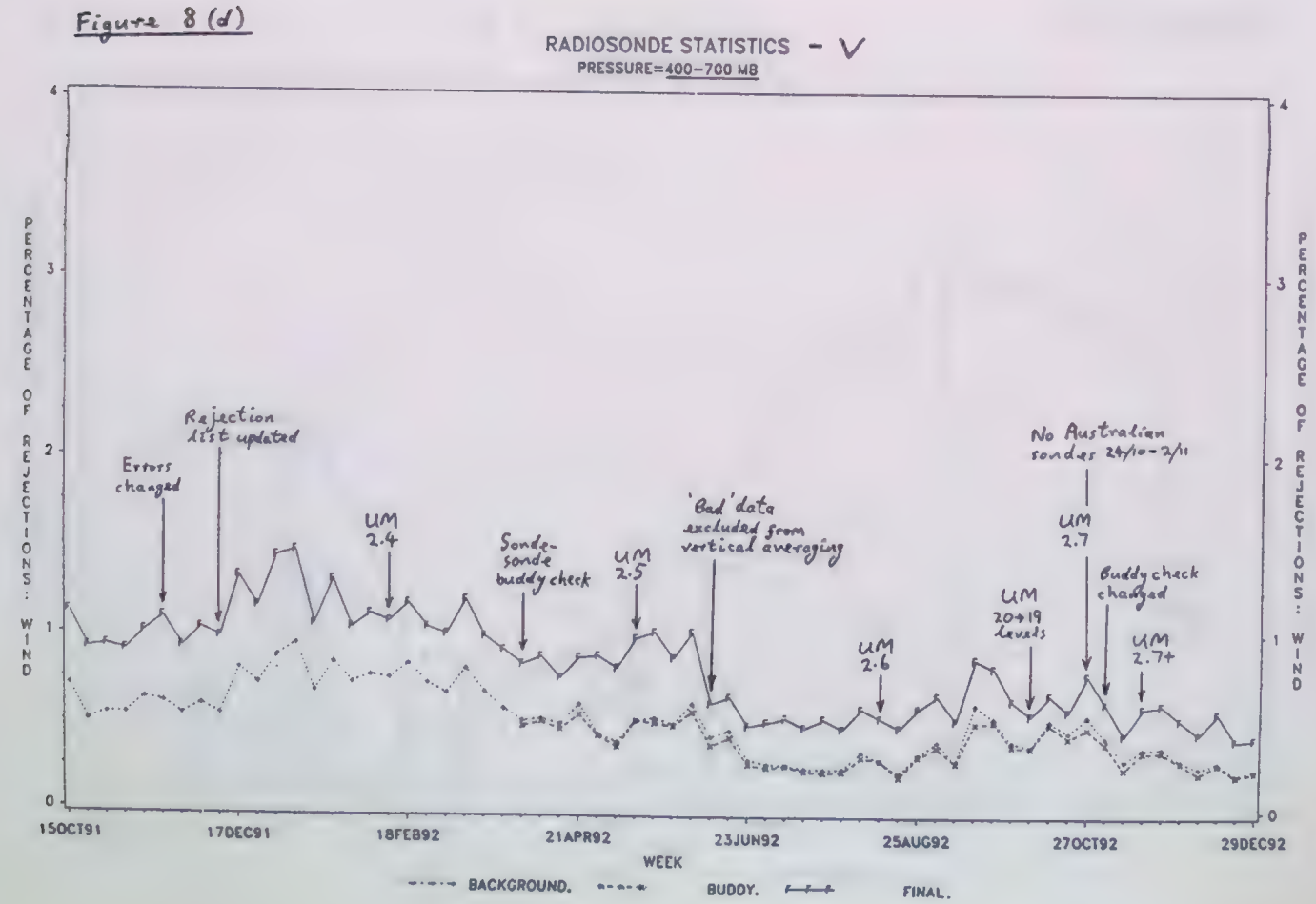

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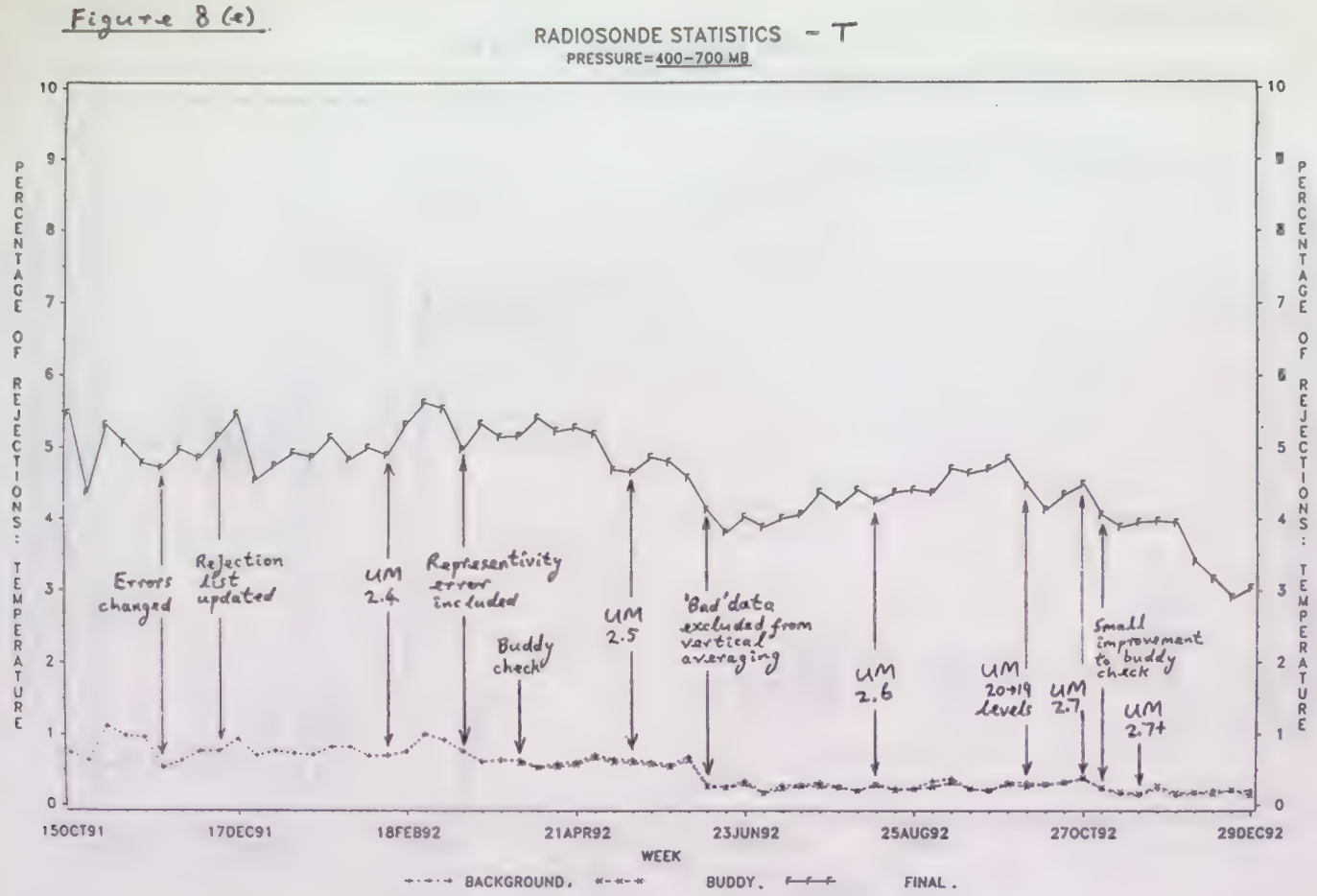

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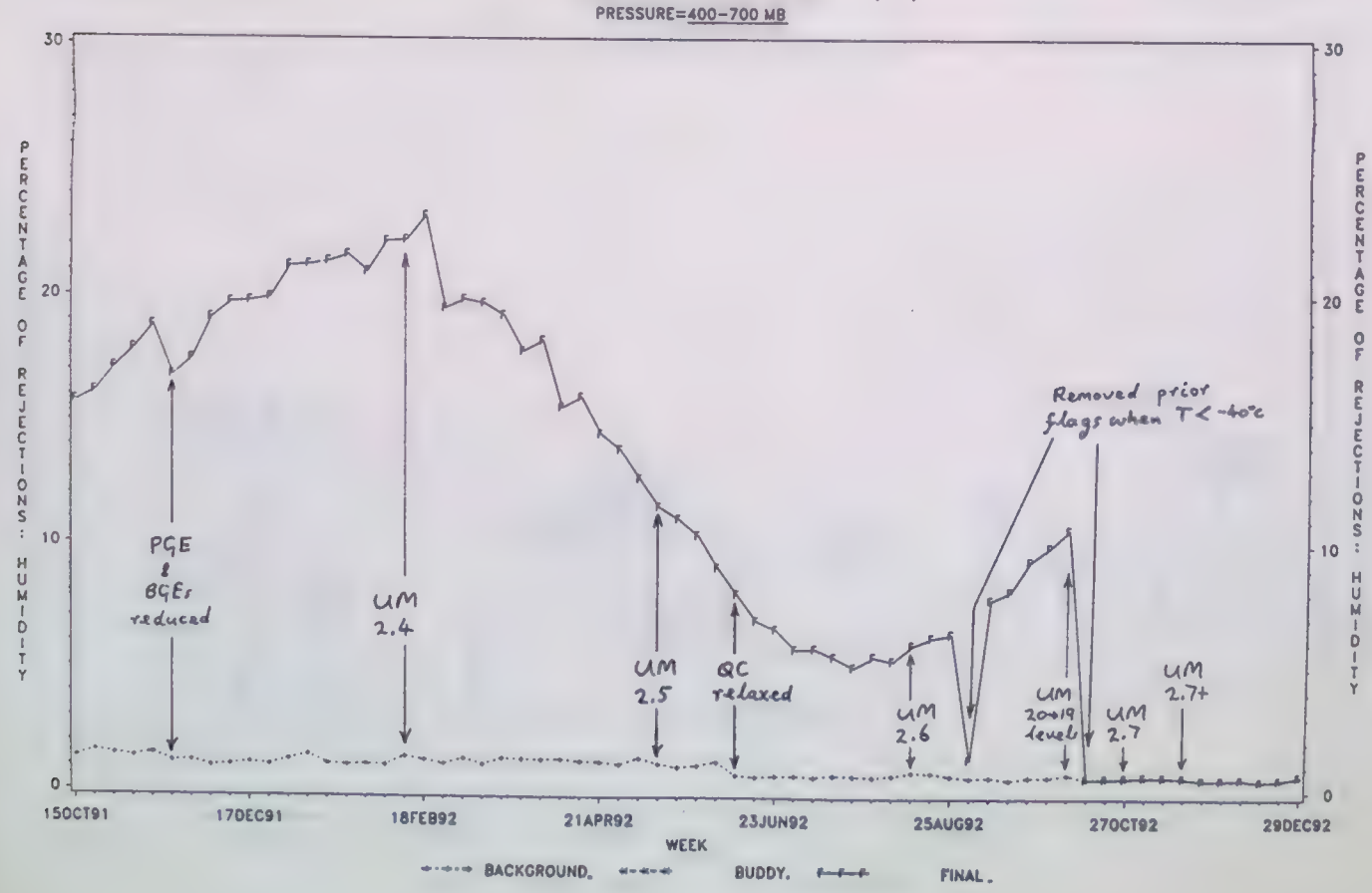

Figure 8(g)

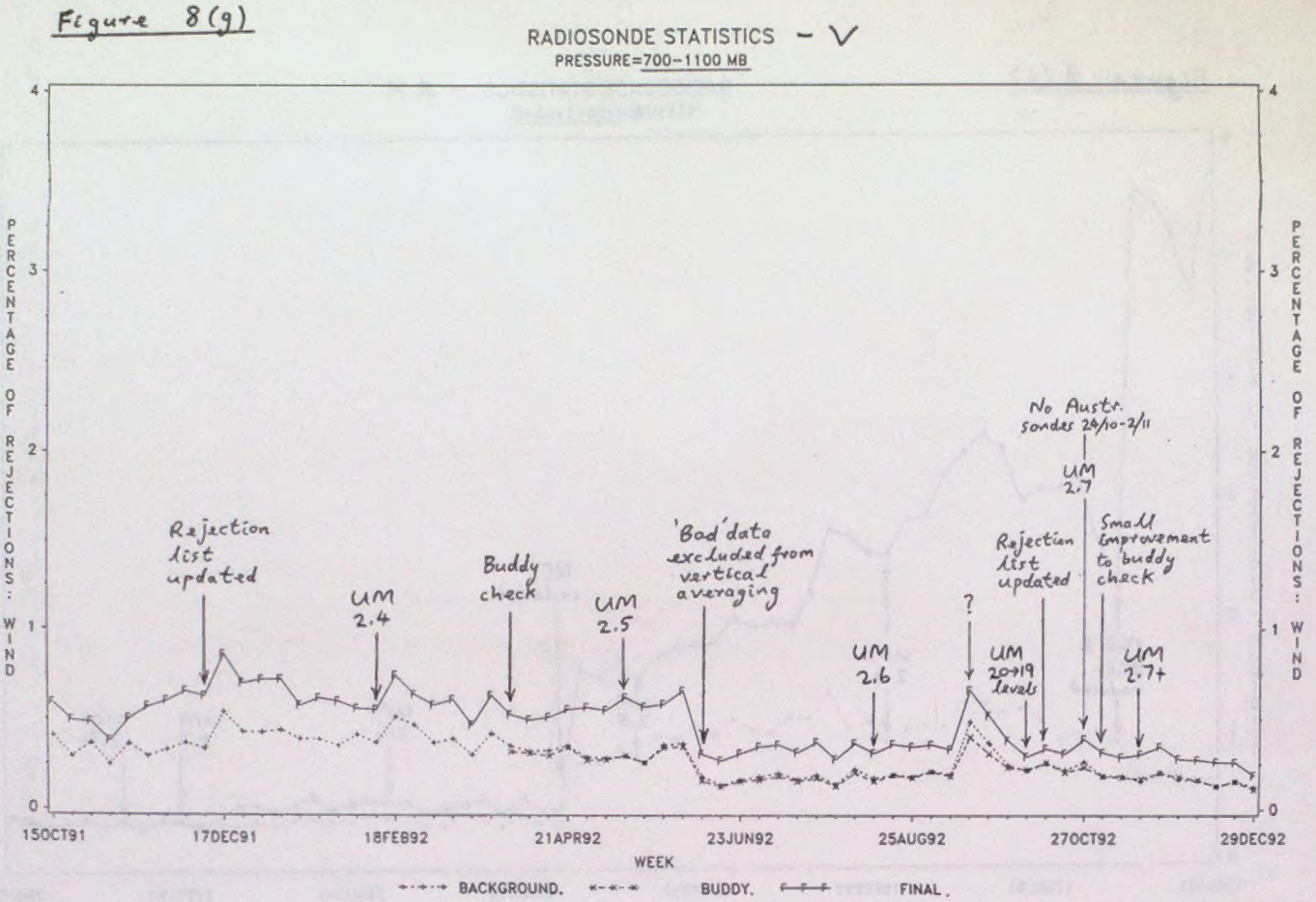

Figure 8(h)

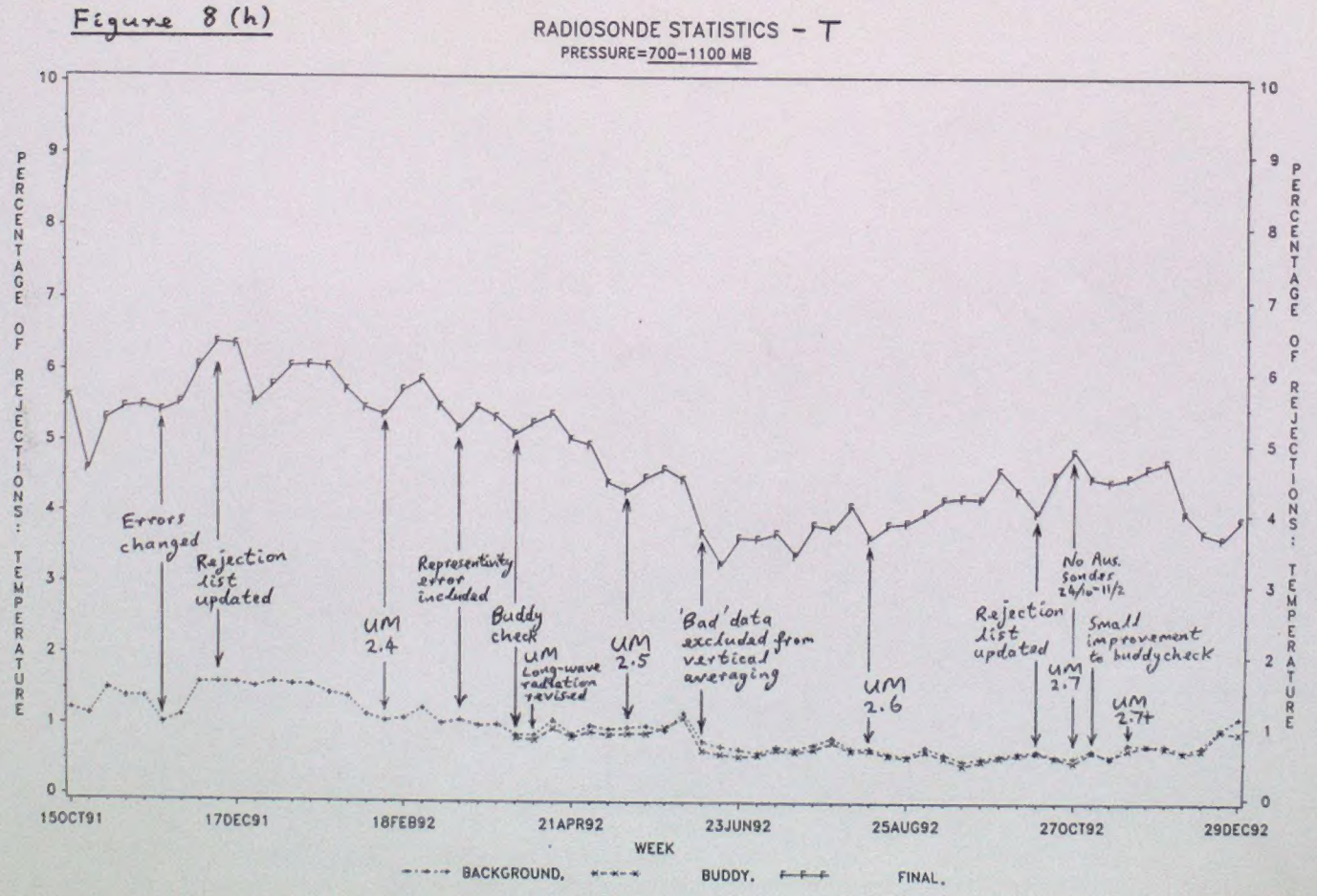

Figure 8 (i)

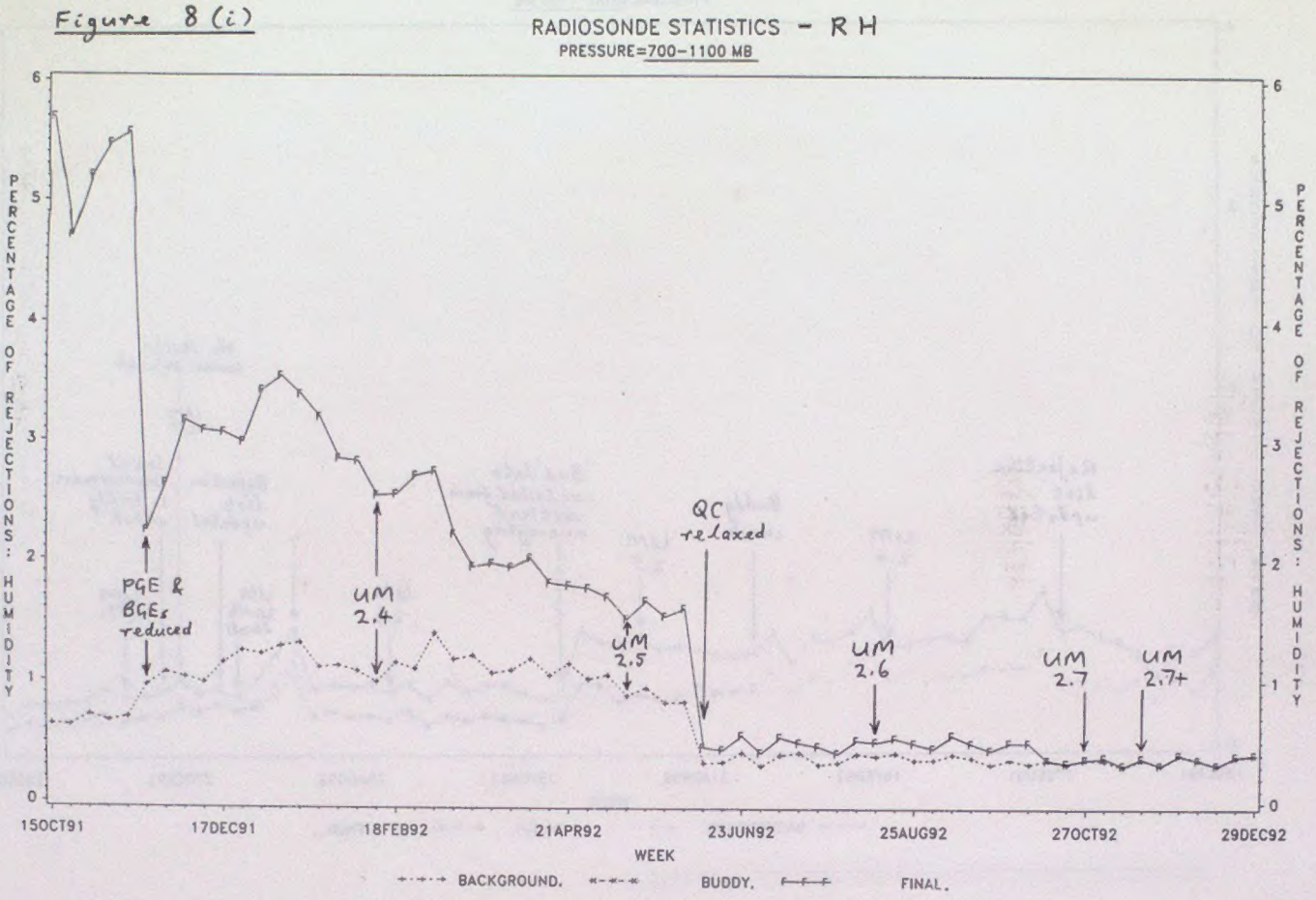
RADIOSONDE STATISTICS - R H
PRESSURE=700-1100 MB
PERCENTAGE OF REJECTIONS: HUMIDITY
PERCENTAGE OF REJECTIONS: HUMIDITY
0
1
2
3
4
5
6
PGE & BGEs reduced
UM 2.4
UM 2.5
QC relaxed
UM 2.6
UM 2.7
UM 2.7+
15OCT91
17DEC91
18FEB92
21APR92
23JUN92
25AUG92
27OCT92
29DEC92
WEEK
BACKGROUND.
BUDDY.
FINAL.

Figure 9.

SATEMS: OCTOBER 1992

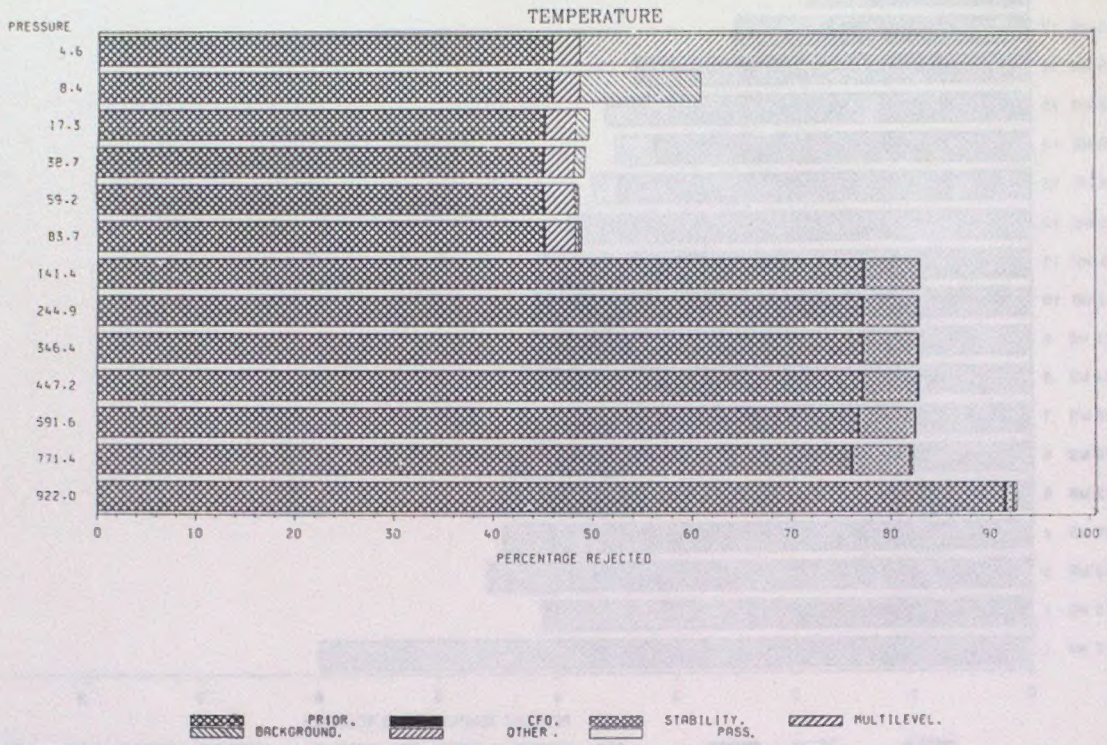

Figure 10 (a)

RADIOSONDES: OCTOBER 1992 - WINDS

THE NOMINAL LAYER PRESSURES CORRESPOND TO P* = 1000 MB

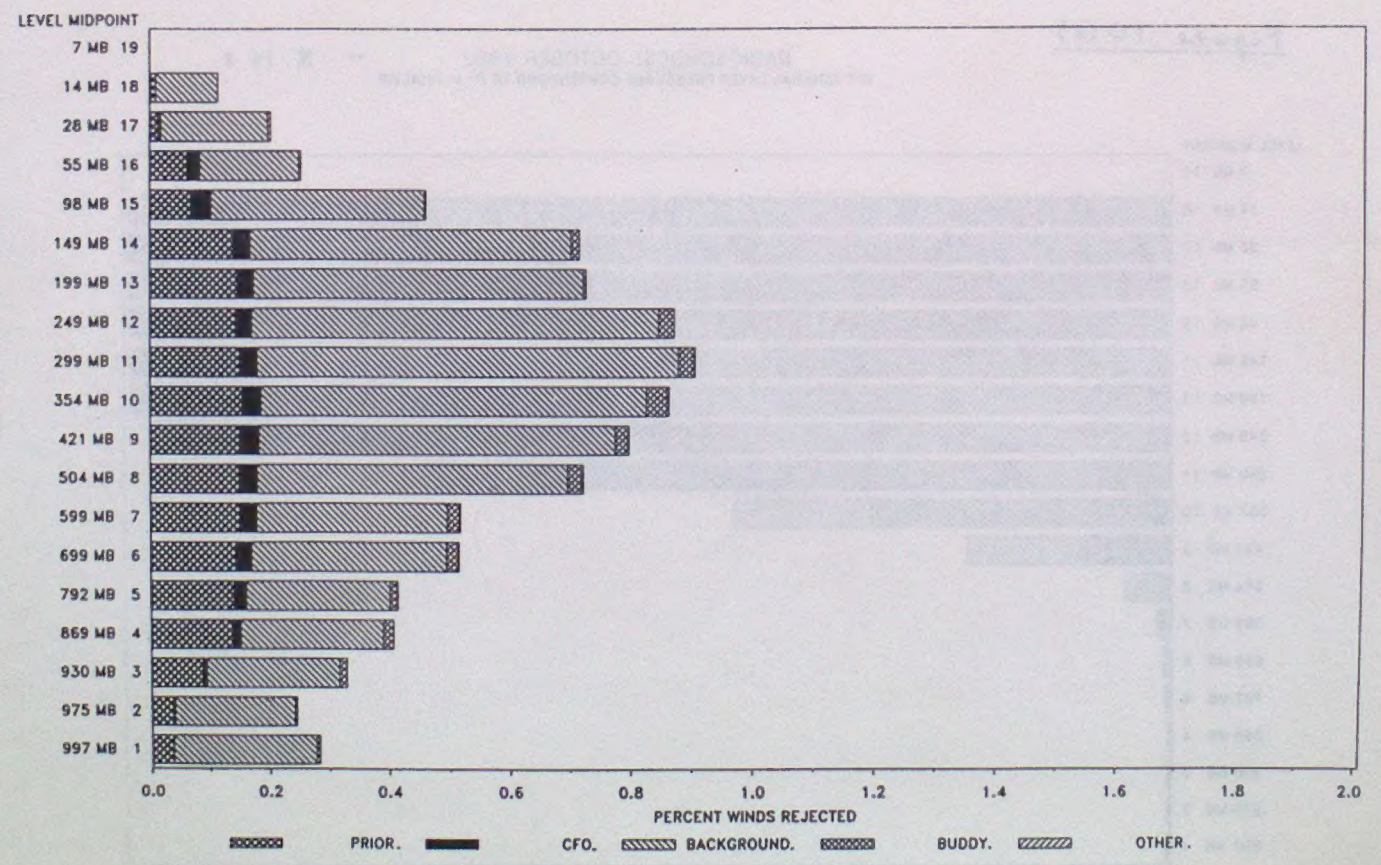

Figure 10 (b)

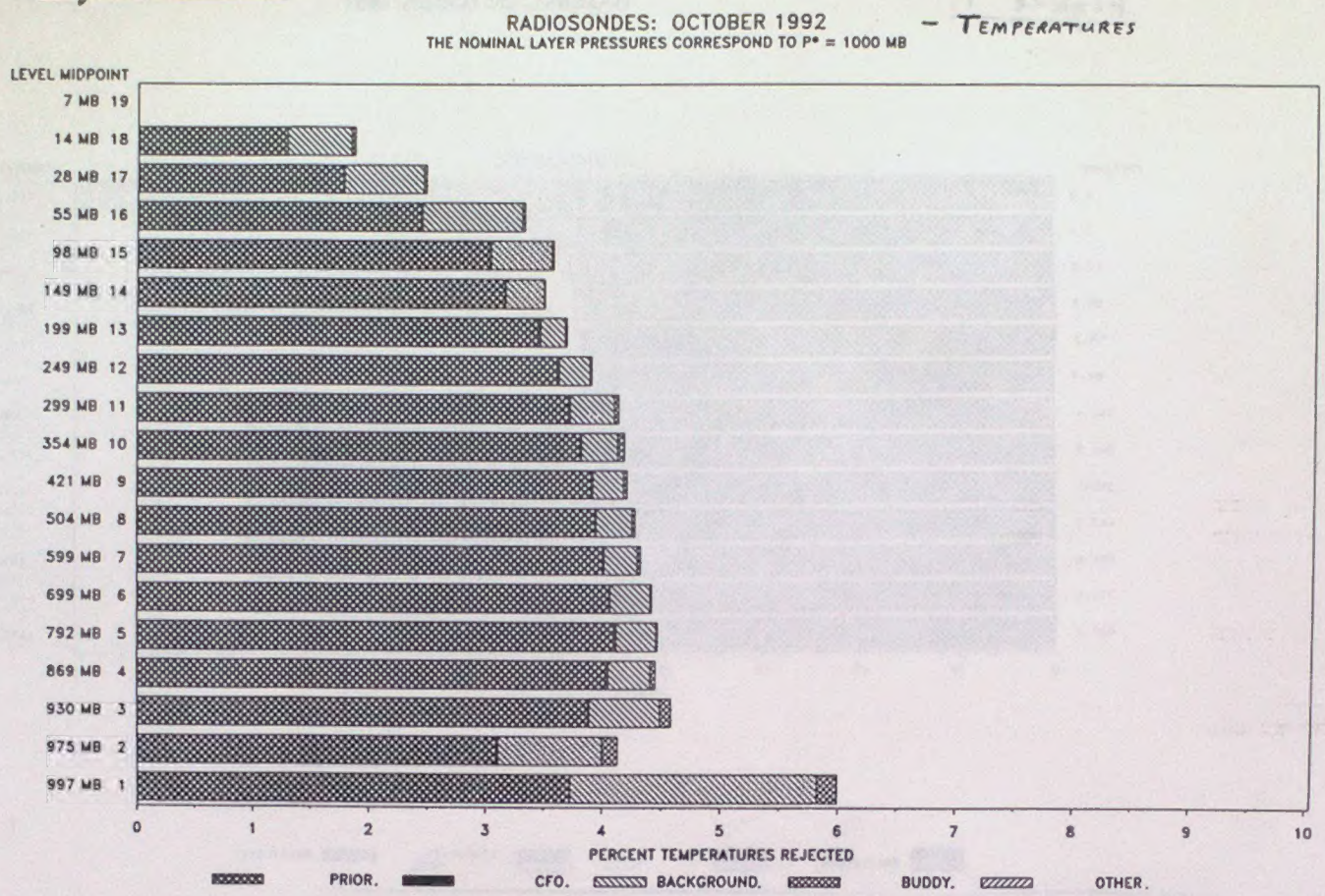
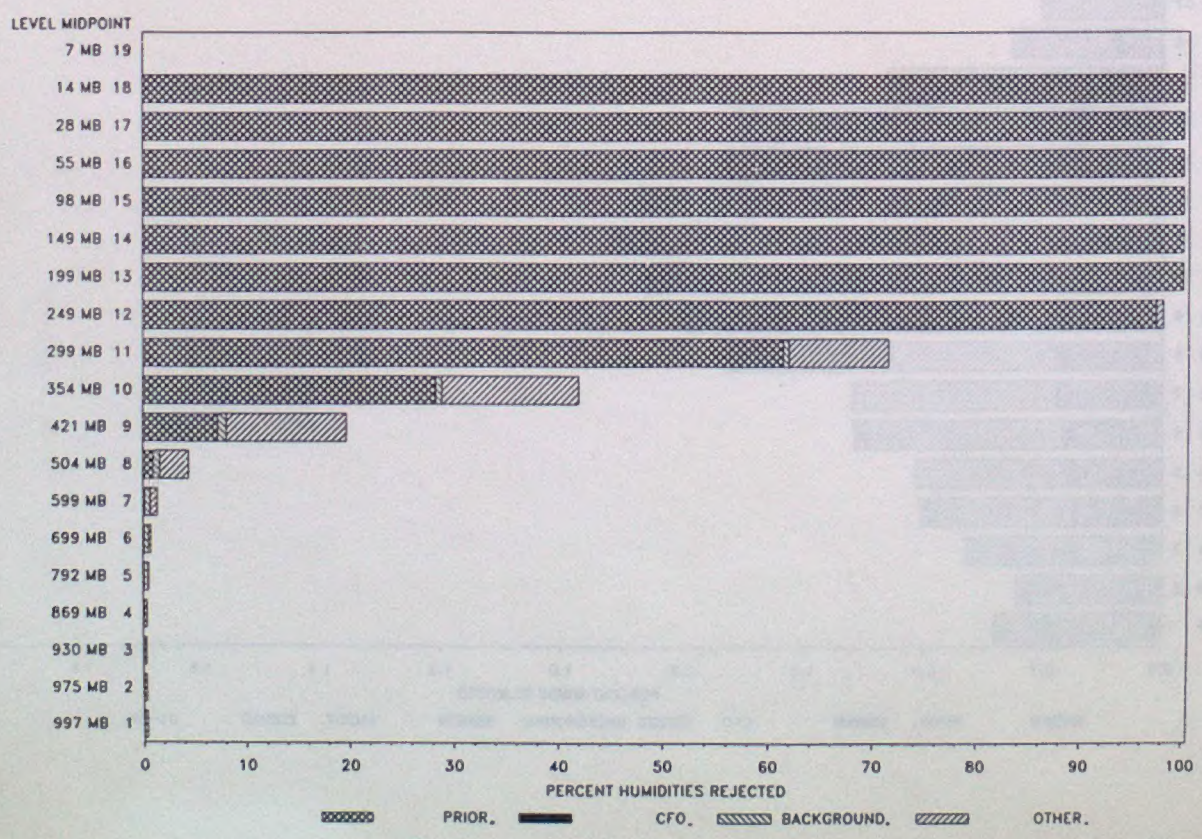
Figure 10 (c)